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Torrey Botanical Club

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 84, NO. 5, pp. 337–355 SEPTEMBER, 1957

A REVISION OF THE GENUS LESCURAEA IN EUROPE AND NORTH AMERICA (CONTINUED)

ELVA LAWTON

6. *Lescuraea stenophylla* (Ren. & Card.) Kindb. Eur. & N. Am. Bryin. 26, 1896.

Leskea rigescens Wils. Ms. (nomen nudum).

Lescuraea rigescens B.S.G. Bryol. Eur. fasc. 46–47. 1851 (nomen nudum).

Hypnum radicosum var. *gracilis* Lesq. & James, Man. N. Am. Mosses 320. 1884.

Pseudoleskea stenophylla Ren. & Card. in Roell, Bot. Centralbl. 44: 421. 1890.

Lescuraea imperfecta C. Muell & Kindb. in Macoun, Cat. Can. Pl. 6: 170. 1892.

Pseudoleskea rigescens Best, Bull. Torrey Club 27: 232–233. 1900.

Plants in loosely spreading mats, green to yellow green; stems prostrate, branching irregularly, rhizoids in tufts; branches mostly straight, rarely somewhat curved at ends; paraphyllia usually numerous, filamentous or lanceolate. Stem leaves straight and symmetric or nearly so, gradually long acuminate with acumen normally longer than body of leaf, lightly plicate, decurrent, reaching 1.6×0.5 mm., but usually smaller, mostly about $1.2–1.4 \times 0.3–0.4$ mm.; margin entire or serrulate at apex, revolute at base; midrib ending below apex; alar cells quadrate; median cells of stem leaves long and narrow, mostly $25–45 \times 6–8$ μ, but in small forms often shorter; basal cells shorter than median cells. Branch leaves smaller, usually serrulate, sometimes revolute at base of acumen as well as at leaf base, more strongly papillose. Papillae common on both sides of lamina and back of midrib, rarely wanting, formed on cell wall at upper end of cell over lumen and sometimes extending over end wall.

Sex organs and bracts similar to those of *L. patens;* seta 5–10 mm. long; capsule typically erect and symmetric, urn $1–1.5 \times 0.7$ mm.; teeth of outer peristome united to form a dark band about three joints wide; lamellae and fine horizontal lines as in *L. patens;* band of endostome no more than one sixth the length of peristome; segments somewhat shorter than teeth, quite narrow, typically without a keel; cilia entirely lacking; spores minutely papillose, 14–18 μ (figs. 66–77).

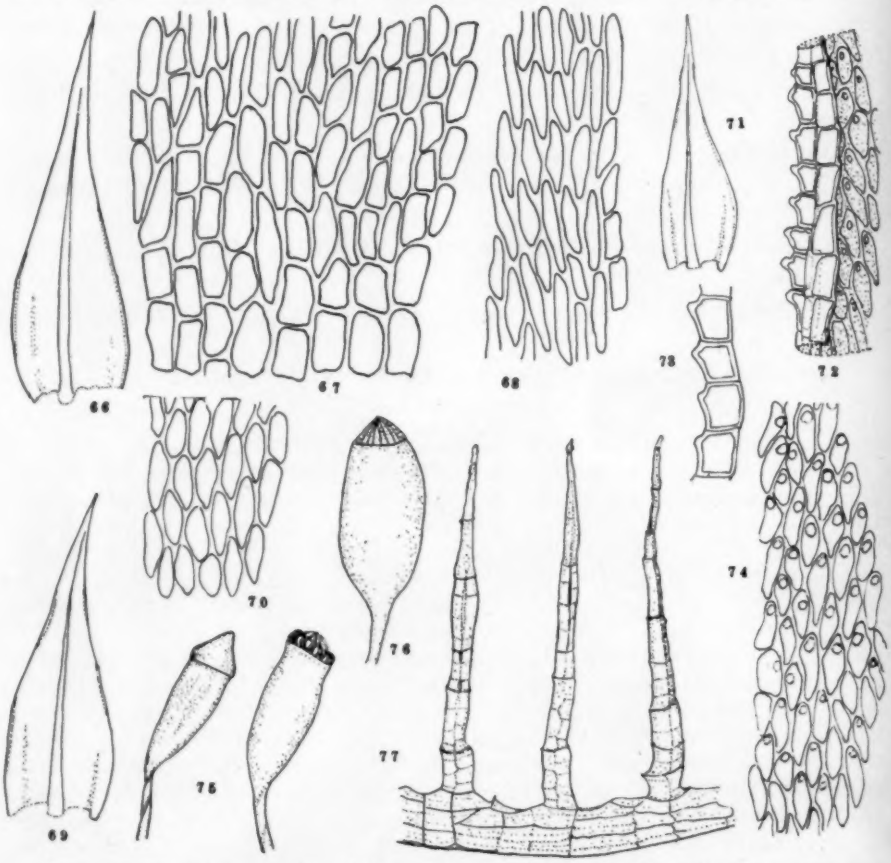
Type: Washington, Roell 672, (holotype probably PC, isotype NY!).

Found on branches of living trees such as alder, willow and maple, rarely on twigs on the ground. Alaska, British Columbia, Alberta, Washington, Oregon, Idaho and Montana.

Illustrations:—Best (1900) pl. 8, f. 10–16, 32, 33; Sharp (1934) pl. 54, f. 10-16, 32, 33.

[THE BULLETIN for July–August 1957 (84: 229–336) was issued September 18, 1957.]

Representative specimens examined:—Alaske, Yakutat Bay, *Trelease 1759, 2056;* Muir Glacier, *1782, 2442, 2452, 2453;* Glacier Bay, Point Gustavus, *Coville & Kearney 753;* the seven specimens listed above are from the Harriman Expedition (MO); Whittier, Lat. 60° 46′ N., Long. 148°



FIGS. 66–77. *Lescuraea stenophylla.* FIGS. 66–68, Drummond. Musci Am. 225, type of *P. rigescens.* FIG. 66. Stem leaf. × 38. FIG. 67. Basal cells of stem leaf from midrib at left to fold at right. × 360. FIG. 68. Median cells of stem leaf. × 360. FIGS. 69–77, Lawton, 2590. FIG. 69. Stem leaf. × 38. FIG. 70. Median cells of stem leaf. × 360. FIG. 71. Branch leaf. × 38. FIG. 72. Revolute margin near apex of branch leaf. × 360. FIG. 73. Longitudinal section of cells near apex of branch leaf. × 360. FIG. 74. Cells of acumen of branch leaf to show papillae. × 360. FIG. 75. Dry capsules. × 14. FIG. 76. Moist capsule. × 14. FIG. 77. Part of inner peristome. × 175.

41′ W., *Harvill 518, 571* (MICH); Kodiak Islands, Port Vista, Raspberry Island, *Eyerdam 875* (S-PA, MICH, LAWTON); Aleutian Islands, Holtz Bay, O'Donnell Valley at 200 ft., *M. B. Howard 752* (MICH, US); Yakutat along Ophir Creek, *Stair & Mazaika 4896, 4903, 4911, 4912, 4916, 5047,*

5152, 5156, 5159, 5161 (MICH). British Columbia, Portage River about Lat. 52° N., Long. 118° W., *Drummond, Musci Am. 225* in part, type of *L. rigescens* (NY); Revelstoke, west side of Columbia River, *Macoun, Can. Musci 489*, type of *L. imperfecta* (S-PA, CAN, WTU); Vancouver Island, Beaver Meadows, *J. W. Bailey,* Aug. 26, 1901 issued by Grout, *N. Am. Musci Pl. 94* (WTU, US, MICH). Alberta: Cameron Lake, Forum Peak, *Crum & Schofield 5734* (CAN). Washington: Kittitas Co., Cascade Mts., at Keechelus Lake near Easton, 1888, *Roell 672* (isotype NY); Mt. Rainier National Park, Upper Valley of the Nisqually River, *Allen, Mosses of the Cascade Mts., 94* (NY, US, MICH, WTU, DUKE, IA); Skamania Co., Martha Creek, 1 mile south of Hemlock Ranger Station, *Weber 2752* (COLO, IA); Clallam Co., Olympic Peninsula, Elwha River Valley, trail from Olympic Hot Springs to Boulder Lake, *Lawton 2590* (WTU, LAWTON); Snohomish Co., 4 miles east of Silverton, base of Big Four Mt., *Lawton 2600* (WTU, LAWTON). Oregon: Clackamas Co., Mollala, Clackamas Tree Farm, *Becking 5308051* (WTU, LAWTON). Montana: Glacier Park, Lake Terry, *M. E. Jones 10991* (IA, LAWTON). Idaho: Traille River Basin, May 1889, *Leiberg 191* (NY, US, MICH).

This species can be distinguished from *L. radicosa* by the narrower leaves which are less strongly revolute, more gradually acuminate and rarely falcate, by the papillae which are over the end of the lumen of the cell at least in part, and by the structure of the endostome. *L. stenophylla* has been reported as growing on rocks as well as on trees but many of these reports are based on incorrect identifications. Very rarely it is found growing mixed with *L. patens* and *L. radicosa* on soil, wood and stones around tree bases. The typical habitat is on the branches of living trees and the habitat is a valuable aid in the identification of sterile specimens.

Pseudoleskea rigescens was described by Lindberg in 1872 and his description precedes that of Renauld and Cardot (Roell 1890) for *P. stenophylla;* but Lindberg described the capsules as "obliqua, cernua" and he gave *Hypnum radicosum* as a synonym. Lindberg's description was based on Drummond's Musci Am. 225 which contains both *L. radicosa* and *L. stenophylla,* but he made no mention of two species in the packet and did not differentiate between them. Hagen in 1909 pointed out that Lindberg had described *P. radicosa* and not *P. rigescens,* although Best (1900) believed that the description applied to *P. rigescens.* To avoid any confusion it is desirable to use the name *L. stenophylla.*

7. **Lescuraea plicata** (Schleich. ex. Web. & Mohr) comb. nov.

Hypnum plicatum Schleich. Crypt. Helv. Exsicc. Cent. IV, 27 (nomen nudum).

Hypnum plicatum Web. & Mohr, Bot. Tasch. 364–365, adnot. *Hypnum rugulosum.* 1807.

Brachythecium plicatum B.S.G. Bryol. Eur. fasc. 52–54. 1853.

Ptychodium plicatum Schimp. Syn. Musc. Eur. 527. 1860.

Lesquereuxia plicata Lindb. Musc. Scand. 36. 1879.

Ptychodium erectum Culm. Revue Bryol. 11: 89. 1884.

Pseudoleskea plicata Kindb. Eur. & N. Am. Bryin. 51. 1896.

Pseudoleskea plicata subsp. *rhaetica* Kindb. Eur. & N. Am. Bryin. 51. 1896.

Ptychodium plicatum var. *erectum* Culm. in Amann, Culmann & Meylan, Catalogue des Mousses Suisse 2: 299. 1918.

Ptychodium plicatum var. *rhaeticum* Amann in Amann, Culmann & Meylan, Catalogue des Mousses Suisse 2: 299. 1918.

Large plants in thick mats, green to yellow green or brown when old; stems prostrate, profusely branched, with tufts of brown rhizoids; branches large, prostrate or suberect, straight or slightly curved at tips; paraphyllia numerous, filiform or lanceolate, not branched. Stem leaves imbricate, ovate-lanceolate, rather abruptly acuminate with a short or long acumen, symmetric or somewhat secund and asymmetric, strongly plicate with several deep folds, decurrent, 2.5–3 × 0.75–1.0 mm., according to Limpricht (1895) reaching 3.5 × 1.5 mm.; margin entire or nearly so, strongly recurved except at apex; midrib strong, ending below apex; alar cells quadrate; median cells 35–55 × 5–7 μ; basal cells somewhat broader than median, thick walled and pitted. Branch leaves smaller and more often serrulate at apex. All cells smooth.

Perigonial bracts ovate, entire, without midrib or with a faint midrib at base, inner ones pointed; antheridia 10–15, paraphyses present; outer perichaetial bracts ovate, inner larger, acuminate, midrib weak or none. Seta 1.5–2.5 cm. long; capsule curved and asymmetric, urn 2–2.5 × 1 mm.; operculum with short beak; outer peristome teeth about 0.5 mm. long, united to form a dark band about four joints wide, with well developed lamellae and fine horizontal lines except at papillose apex; endostome with basal membrane one fourth to one third its length; segments broad, keeled, sometimes open on part of keel, smooth or somewhat papillose, about as long as teeth; cilia none or rudimentary; spores somewhat rough, 15–20 μ (figs. 78–83).

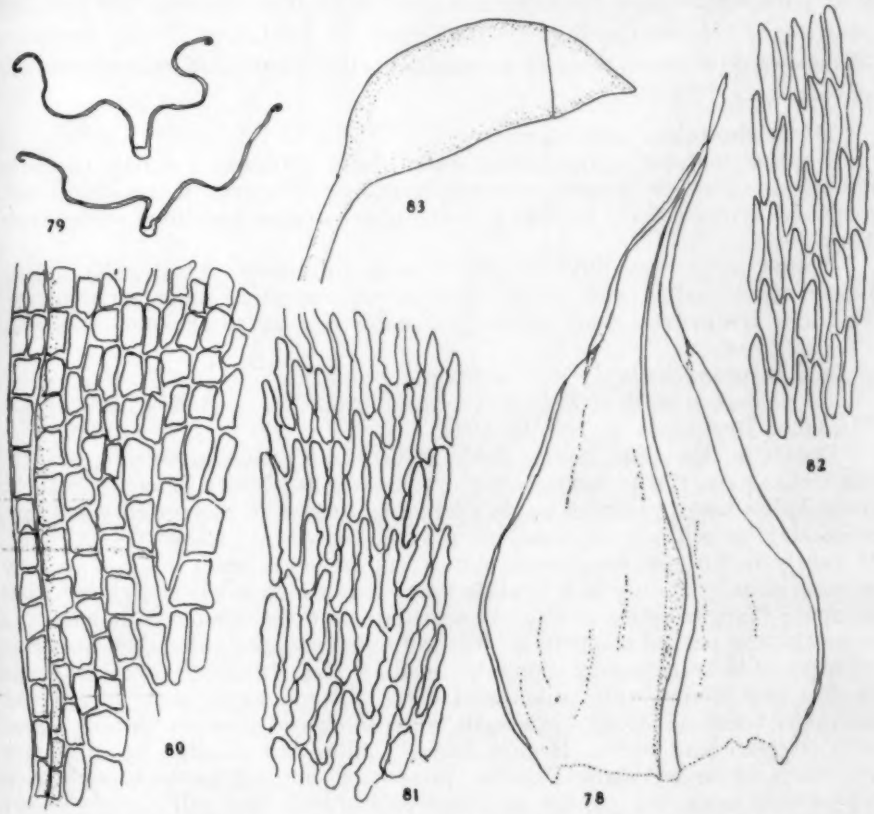
Type: Switzerland, Schleicher, IV, 27, not seen. This description is based on Wartman & Schenk, Schweiz. Krypt. 293 (NY).

On rocks, usually calcareous, in mountains of southern Europe, Scandinavia and Scotland.

Illustrations:—B.S.G. (1853) pl. 555; Braith. (1900) pl. 107 C; Broth. in Engler & Prantl (1925) f. 760 A-D.

Representative specimens examined:—Switzerland: Wallis, Tanney, *Amann,* Sept. 28, 1928, Bauer *Musci Eur. 2097b* from the type locality (NY); Saleve bei Genf, Bernet Sept. 1862 and Churwalden in Tannenwälden, *Dr. Killias,* 1863 issued by Wartman & Schenk, *Schweiz. Krypt. 293* (NY). Germany: Riesengebirge, der Kleinen Schneegrube, *Limpricht,*

Oct. 1, 1866, *Bryotheca Silesiaca 140* (NY). Austria: Tirol, south side of Kitzbuehel Horn, *Crundwell 111* (CAN, LAWTON). France: Gavarnie, Hautes-Pyrenées, Husnot, *Musci Gall. 440* (NY). Italy: Prov. Comensis, Monte Palanzolo above Palanzo, *Artaria,* Sept. 29, 1897 (CAN). Scotland: Perthshire, Ben Lawers, *Wilson 343* (NY, MICH), *Crundwell,* July 30,



FIGS. 78–83. *Lescuraea plicata,* Wartman & Schenk, Schweiz. Krypt. 293. FIG. 78. Stem leaf. × 38. FIG. 79. Cross sections of stem leaves near middle and above middle. × 38. FIG. 80. Alar cells of stem leaf. × 360. FIG. 81. Basal cells of stem leaf. × 360. FIG. 82. Median cells of stem leaf. × 360. FIG. 83. Capsule. × 14.

1953 (CAN). Norway: Finnmarkens, *Kaurin,* Aug. 1894 (CAN). Sweden: Jämtland, *C. Stenholm,* Aug. 21, 1918 (MICH).

L. plicata is the largest species of the genus but only slightly larger than *L. radicosa* var. *denudata* from which it is easily distinguished by the strongly plicate leaves and by the pits in the walls of the basal cells. Although *L. plicata* has been placed in other genera and other families, for example in *Brachythecium* and in the *Rhytidiaceae,* it is clear that it is

most closely related to *L. radicosa*. It resembles *L. radicosa* in the shape of the capsule and the structure of the peristome. The paraphyllia are abundant and unbranched as in all of the *Pseudoleskea* subgenus, a character which removes it from *Brachythecium*, a genus without paraphyllia. The members of the Rhytidiaceae of Fleischer (1915–1922) and Brotherus (1925) which bear paraphyllia have the branched kind as in *Hylocomium*. The detailed drawing of the basal cells of the leaf given by Brotherus (1925) in figure 760 shows cells which seem to be papillose, but all cells of this species are smooth.

B. Tricholeskea subgen. nov.

Plantae majores, paraphyllia nulla, folia pilifera; cellulae basilares oblongo-lineares, incrassatae, porosae, medianae breviorae, alares quadratae. Capsula symmetrica; dentes peristomiales similes dentibus subgeneris Psudoleskeae.

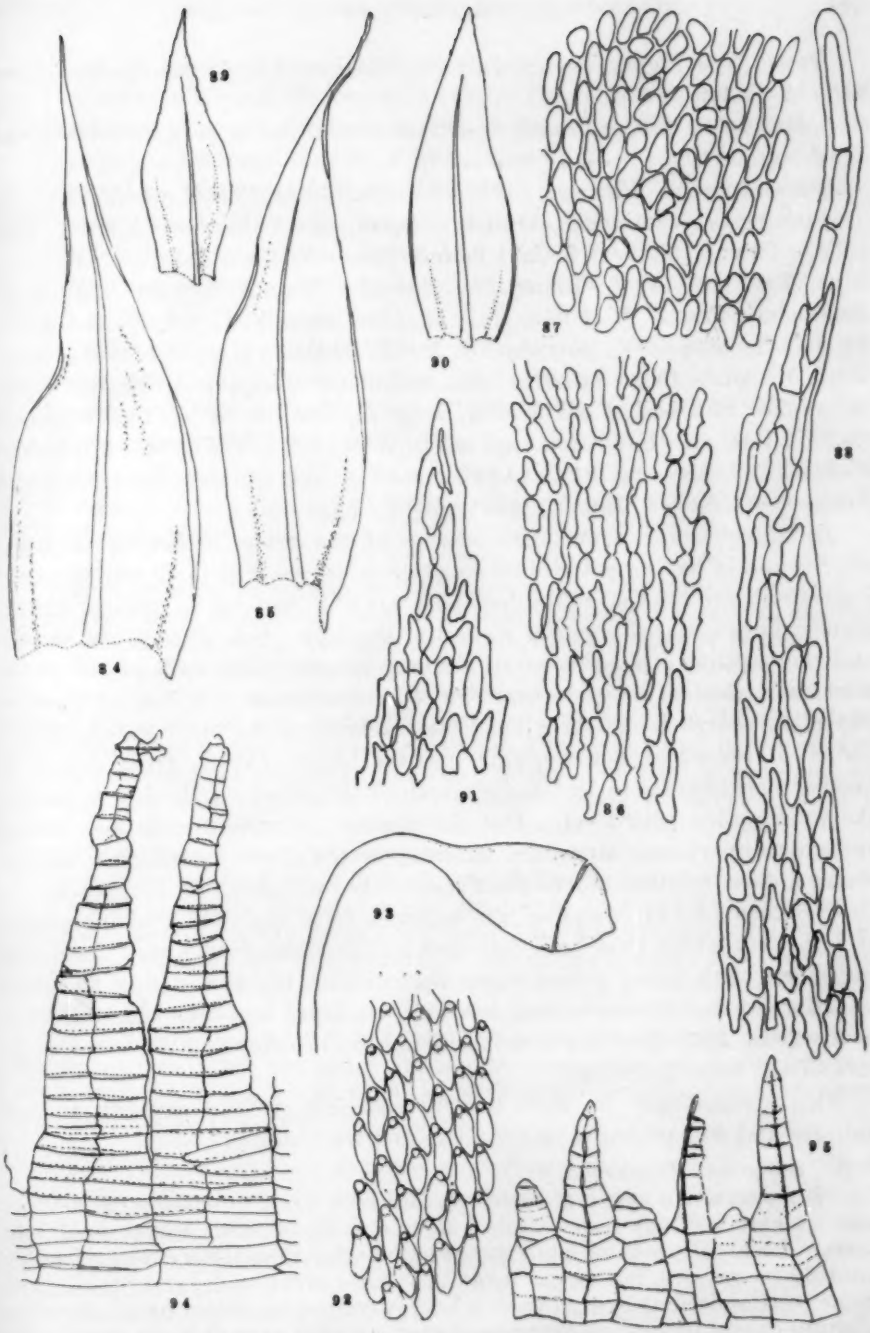
Plants large, paraphyllia none, leaves piliferous; basal cells oblong linear, thick walled and pitted, median cells shorter, the alar quadrate. Capsules symmetric; teeth of the peristome similar to those of subgenus *Pseudoleskea*.

8. **Lescuraea baileyi** (Best & Grout) comb. nov.

Pseudoleskea Baileyi Best & Grout, N. Am. Musc. Pl. 474, Mar. 1917; Williams, Bryologist 27: 92–93. 1924.

Plants in thin mats, yellow green to brownish; stems prostrate, branching irregularly, the branches straight or nearly so; brown rhizoids in tufts, paraphyllia wanting. Stem leaves spreading when wet, appressed when dry, symmetric or slightly asymmetric, plicate, decurrent, 1.5–2 × 0.4–0.7 mm., or rarely to 2.5 mm. long, acuminate from an ovate base; acumen as long as base, usually ending in a hyaline hair point which is sometimes recurved at apex; margin entire or slightly serrulate at apex, recurved at base and sometimes on part of acumen; midrib ending below apex; alar cells quadrate or some cells transversely elongate; median cells 16–26 × 9–10 μ, variable in size and shape, walls thick and often pitted; basal cells longer and narrower reaching 30–40 μ in length, walls thick and strongly pitted; apical cells elongate and pitted. Branch leaves similar but smaller, apex shorter and more often serrulate. Papillae present, prominent on back of branch leaves near apex, the papilla at upper end of cell over cell cavity; upper side of leaf smooth or with small papillae.

Perigonial bracts very concave, entire, without midrib or with a faint rib, cell walls sometimes pitted; antheridia several, filamentous paraphyses present; outer perichaetial bracts ovate, short, without midrib; inner bracts larger, long acuminate, with weak midrib, cell walls mostly pitted, paraphyses present. Seta about 1 cm. long; capsule symmetric but inclined by curved seta; urn about 1.5 × 1 mm.; outer peristome teeth to about 0.4 mm. long, sometimes irregular, plainly lamellate, with fine horizontal lines except at apex, united at base, the union variable, forming a dark band 4–8 joints wide, about one fourth the length of exostome; endostome with a keeled basal membrane about one fourth the length of outer teeth; segments poorly developed, sometimes partly adherent to teeth, keeled, often open on keel; cilia none or very rudimentary; spores rough, 16–22 μ (figs. 84–95).



FIGS. 84–95. *Lescuraea baileyi*. FIGS. 84–92. Bailey, 1916, type. FIGS. 84 and 85. Stem leaves. × 38. FIGS. 86, 87 and 88. Basal, median and apical cells of stem leaf. × 360. FIGS. 89 and 90. Branch leaves × 38. FIG. 91. Apical cells of old branch leaf. × 360. FIG. 92. Cells from upper part of young branch leaf to show papillae. × 360. FIGS. 93–95, Bailey, 1924. FIG. 93. Capsule. × 14. FIG. 94. Part of outer peristome. × 175. FIG. 95. Part of inner peristome. × 175.

Type: Washington, Bailey, July 19, 1916 issued by Grout, N. Am. Musci Pl. 474 (holotype NY!).

Usually on twigs or branches of trees, sometimes on rock, in Alaska and Washington.

Illustrations:—Williams (1924) pl. 13; Sharp (1934) pl. 55, f. 1–14.

Specimens examined:—Alaska: Juneau, *A. Mehner 6*, Apr. 4, 1904 (NY); Thumb Bay near Knight Island, Prince William Sound, *L. Norberg*, Sept. 1940 (S-PA). Washington: Cascade Summit, Sunset Trail near Snoqualmie Pass, *J. W. Bailey*, July 19, 1916 issued by Grout, *N. Am. Musci Pl. 474* (holotype NY, isotypes US, MICH, S-PA); King Co., Silver Peak Trail, Rockdale Creek near the west end of the Snoqualmie Tunnel of the Milwaukee Railroad, *J. W. Bailey*, Aug. 31, 1924, c. fr. (NY); Whatcom Co., Mt. Baker, *J. M. Grant*, Aug. 1929 (WTU, IA, LAWTON); Mt. Baker, *Shallert 272*, Sept. 9, 1945 (IA); Pierce Co., Mt. Rainier, Commonwealth Trail, *J. W. Bailey*, July 23, 1931 (WTU, IA).

L. baileyi differs from other species of the genus in having no paraphyllia and in having hair points on the stem leaves. The thick-walled pitted cells which are longest at the leaf base are outstanding. *L. plicata* and *L. atricha* have cells with pitted walls but the cells of *L. plicata* are smooth and the papillae of *L. atricha* are formed by projecting ends of cell walls, while in *L. baileyi* they are over the cell cavities, one per cell. In gametophyte characters *L. baileyi* is not closely related to the other species of the genus; it resembles *Lesquereuxia robusta* Lindb. (1872) from Japan in lacking paraphyllia, in leaf shape, in the hair points on the leaves and in the thick-walled pitted cells. But *L. robusta* has smooth cells and differs radically in peristome structure. In the structure of the peristome *L. baileyi* shows a clear relationship to the *Pseudoleskea* subgenus of *Lescuraea*.

Williams (1924) described the capsules from the only fruiting plants of *L. baileyi* which have been collected and he illustrated a well developed endostome with broad keeled segments, open on the keel. Using the same material, I found the endostome less well developed and somewhat adherent to the teeth. More fruiting material is needed to determine the true structure of the inner peristome.

This species may be more widely distributed than present records indicate and will probably be found in British Columbia.

C. Subgenus *Lescuraea*.

Plants small to medium sized, paraphyllia from numerous to few or none; leaves without hair points; median cells of stem leaves long and narrow, basal cells also long but somewhat shorter than the median; papillae wanting or present but never large. Capsules erect and symmetric; peristome teeth united at base to form a narrow yellow or brown band; lamellae wanting except in *L. iliamniana;* endostome with a narrow basal membrane, one tenth or less the length of the inner peristome; segments narrow, not keeled, cilia wanting.

Type species, *Pterogonium striatum* Schwaegr.

9. *Lescuraea striata* (Schwaegr.) B.S.G. Bryol. Eur. fasc. 46–47. 1951.

Pterogonium striatum Schwaegr. Suppl. Sp. Musc. 1(1): 103–105. 1811.

Pterigynandrum mutabile Brid. Musc. Recent. Suppl. 4, Mant. 129. 1819.

Maschalocarpus striatus Spreng. in Linn. Syst. veg. 4(1): 158. 1827.

Neckera striata Schwaegr. Suppl. Sp. Musc. 3(1). 1828.

Pterigynandrum striatum Duby, Bot. Gall. 563. 1830.

Isothecium striatum Spruce, Musc. Pyren. 93. 1847 in Trans. Bot. Soc. Edinb. 3(3): 147. 1850 (not seen).

Leptohymenium striatum Rabenh. Kryptfl. Deutschl. 2(3): 249. 1848.

Anomodon striatus Hartm. Skand. Fl. ed. 8. 351. 1861.

Leskea mutabilis Boul. Fl. Crypt. l'Est, Musc. 325. 1872.

Lesquereuxia mutabilis Lindb. Acta Soc. Sci. Fenn. 10: 247. 1872.

Pseudoleskea striata Dix. in Dix. & James. Brit. Mosses, ed. 2. 423. 1904.

Lescuraea mutabilis (Brid.) Hagen, Kgl. Norske Vidensk. Selsk. Skr. 1908(9): 53. 1909.[1]

Plants growing in patches or mats, green to yellow green; stems prostrate, branching irregularly, the stems and branches not curved at tips; brown rhizoids in tufts; paraphyllia numerous, filamentous or lanceolate. Stem leaves spreading when moist, imbricate when dry, symmetric, long and narrow, tapering gradually to a long fine point, plicate, decurrent, mostly 1.6×0.35–0.6 mm., but sometimes reaching 2 mm. in length; margin entire, recurved for most of length; midrib often extending nearly to apex but not percurrent; alar cells quadrate; median cells 5–7 μ wide and 4–8 times as long with some cells 70–80 μ long: basal cells also long, 3:1 or more, not usually pitted. Branch leaves smaller, usually entire, rarely slightly serrulate at apex in young leaves. All leaves usually smooth, rarely a few papillae on back of midrib at tips of young branch leaves.

Perigonial bracts and antheridia similar to those of *L. patens;* perichaetial bracts abruptly acuminate, cells long and narrow, midrib weak, paraphyses usually present. Seta 5–8 mm. long; capsule erect and symmetric, urn 1.4–1.7×0.75 mm.; operculum conic; peristome to 0.32 mm. long; the teeth without lamellae, papillose, united at base to form a narrow yellow to yellow brown band 1–3 joints wide; endostome with narrow basal membrane less than one tenth its length; segments not keeled, narrow, about two cells wide, shorter than the teeth, papillose; cilia wanting; spores papillose, about 16 μ (figs. 96–102).

Type: Germany, Riesengebirge bordering Czechoslovakia and Silesia, Germany, collected by C. Ludwig, not seen. Neotype: Germany, Bryoth. Sil. Limpr. 179 (NY!).

On trees in alpine regions of southern Europe.

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[1] This will be the correct name in the event that the starting point for moss names is changed to Apr. 19, 1801. Bridel published the name *Hypnum mutabile* in Muscologia Recentiorum 2(2): 170–171. 1801. According to Sayre (1957) the date for Bridel's work is May 9, 1801.

Illustrations:—Bridel (1801) pl. 6, f. 1; Schwaegr. (1811) pl. 27; Schwaegr. (1828) pl. 246; B.S.G. (1851) pl. 459.

Representative specimens examined:—Germany: Riesengebirge bei St. Peter, *Limpricht*, July 29, 1867, *Bryoth. Sil. 179* (NY). Bohemia: Reichenberg, *W. Siegmund*, June 1858 issued in Rabenh., *Bryoth. Eur. 150* (NY). Austria: Riesalpe & Staff prope Lilienfeld, *Baumgartner 3098* (NY, US). Switzerland: Dôle, Bernet, Aug. 1862 issued by Wartman & Schenk, *Schweiz Krypt. 292* (NY). Italy: Nell'Appennino di Garfagnana al Monte Giovarello, Bottini Aug. 1882 issued in *Erb. Critt. Ital. ser 2, 1212* (NY).

L. striata is distinguished by erect capsules and teeth without lamellae, by the non-falcate leaves which are usually quite smooth and entire, by the very long narrow leaf cells and by the habitat on trees. According to Meylan (1938) it may grow on calcareous rock. The transition from median to basal cells is gradual and the long basal cells are outstanding. The other species of the subgenus *Lescuraea* also have long cells at the leaf base but the leaves are toothed and papillose. The basal cells of *L. plicata* and *L. baileyi* are long but the walls are strongly pitted.

10. *Lescuraea saxicola* (B.S.G.) Milde, Bryol. Siles. 288. 1869.

Lescuraea striata var. *saxicola* B.S.G. Bryol. Eur. fasc. 46–47. 1851.

Anomodon striatus var. *saxicola* Hartm. Skand. Fl. ed. 8. 351. 1861.

Lescuraea saxicola Molendo in Lorentz, Moosstud. 144, 147, 149. 1864 (nomen nudum).

Lescuraea insignis De Not. Epil. 216, adnot. 1869.

Lesquereuxia saxicola Lindb. Not. Sällsk. Faun. Fl. Fenn. Förh. 11: 71. 1871.

Isothecium striatum var. *saxicola* Boul. Musc. France 143. 1884.

Ptychodium decipiens Limpr. Die Laubm. 2: 799–801. 1895.

Lescuraea frigida Kindb. Eur. & N. Am. Bryin. 26. 1896.

Pseudoleskea substriata Best, Bull. Torrey Club 27: 233–234. 1900.

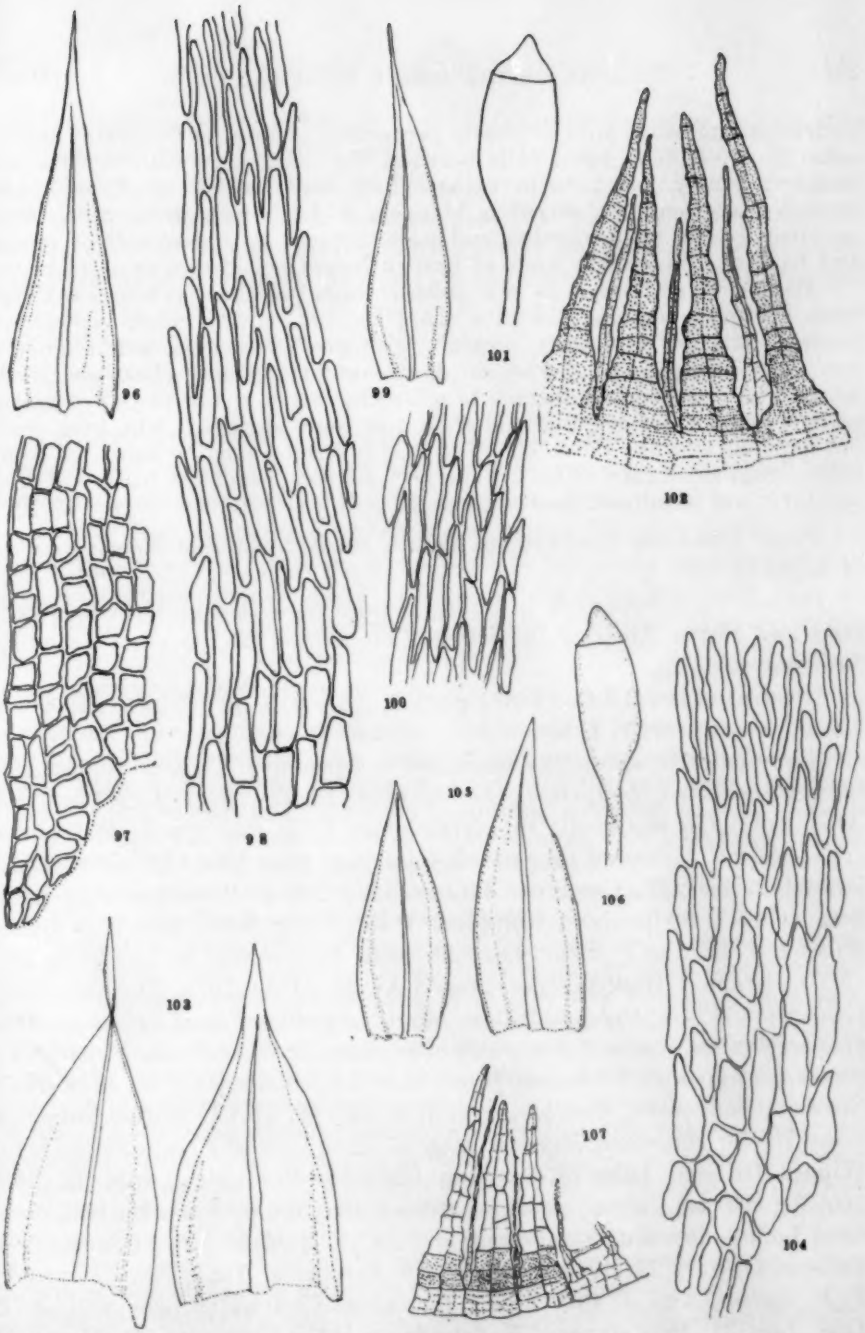
Pseudoleskea striata var. *saxicola* Dix. in Dix. & James. Brit. Mosses, ed. 2. 423. 1904.

Lescuraea mutabilis var. *saxicola* Hagen, Kgl. Norske Vidensk. Selsk. Skr. 1908(9): 53–58. 1909.

Lescuraea mutabilis var. *decipiens* Moenkem. Die Laubm. Eur. 692. 1927.

Pseudoleskea frigida Sharp in Grout, Moss Fl. N. Am. 3: 190. 1934.

Plants in mats, yellow green to brownish, glossy, rather compact due to the numerous closely placed branches; stems and branches often hooked at ends; rhizoids not numerous, in tufts on main stems; paraphyllia usually plentiful at least on stems, filamentous or lanceolate. Stem leaves usually somewhat falcate and asymmetric, but sometimes nearly straight, plicate, decurrent, 1–1.6 × 0.3–0.7 mm.; well developed stem leaves abruptly acuminate to a fine point, but such leaves often lacking and all leaves rather blunt at apex; margin recurved nearly to apex, entire or serru'ate at apex;



FIGS. 96–102. *Lescuraea striata.* FIGS. 96–98, Rabenh. Bryoth. Eur. 150. FIG. 96. Stem leaf. × 38. FIG. 97. Alar cells of stem leaf. × 360. FIG. 98. Basal, transitional and median cells of stem leaf. × 360. FIGS. 99–102, Limpricht, Bryoth. Sil. 179. FIG. 99. Branch leaf. × 38. FIG. 100. Median cells of branch leaf. × 360. FIG. 101. Capsule. × 14. FIG. 102. Part of peristome. × 175

FIGS. 103–107. *Lescuraea saxicola.* FIGS. 103–105, Limpricht, Bryoth. Sil. 79. FIG. 103. Stem leaves. × 38. FIG. 104. Basal, transitional and median cells of stem leaf with a few of the stem cells at base. × 360. FIG. 105. Branch leaves. × 38. FIGS. 106 and 107, Molendo 63. FIG. 106. Capsule. × 14. FIG. 107. Part of peristome. × 175.

midrib ending below apex or nearly percurrent; alar cells quadrate; median cells 32–50 × 6–8 μ: basal cells between the folds somewhat shorter and broader, mostly 2–3:1, with rather thick walls which show some pits. Branch leaves smaller, serrulate at apex, midrib often percurrent. Small papillae formed by projecting end walls present on upper side of lamina and back of midrib near apex of branch leaves, sometimes on stem leaves.

Antheridia and bracts as in *L. patens;* inner perichaetial bracts to 2 mm. long, abruptly acuminate with a short acumen, midrib weak, paraphyses present; seta 6–9 mm. long; capsule erect and symmetric, urn 1–1.6 × 0.6 mm., operculum conic; peristome double but endostome often poorly developed and sometimes adhering to columella; teeth yellow to yellow brown, usually smooth but sometimes slightly papillose, about 0.2 mm. long, without lamellae and fine lines, united at base to form a narrow band 1–2 joints wide; basal membrane of endostome very narrow; segments weak and fragmentary, not papillose; spores about 16 μ, finely papillose (figs. 103–107).

Type: European Alps without definite locality, not seen. Neotype: Tirol, Molendo 63 (NY!).

On non calcareous rock in alpine regions of continental Europe, Scotland and North America in British Columbia, Utah, Quebec, Labrador, Vermont.

Illustrations:—B.S.G. (1851) pl. 459, f.β1, β1b, β2; Braith. (1900) pl. 107 F; Broth. (1925) f. 654.

Representative specimens examined:—Germany: Kleinen Schneegrube im Riesengebirge, *Limpricht,* Oct. 2, 1866, *Bryoth. Sil. 79* (NY). Tirol: Alps, Coldilano et Ornella in Livinallongo, *Unio itin. crypt. Molendo 63* (NY); Tirol, Wattental prope Hall, *Schiffner,* Aug. 1900 (NY, US). Italy: Prov. Comensis, Mt. Camisolo, *Artaria,* 1897, det. as *P. decipiens* by Kindberg (CAN). Switzerland: Simplon, *Wälde,* July 1903, issued by Bauer, *Musci Eur.* 622a as *P. atrovirens* and called *P. decipiens* by Loeske in 1911 (NY). France: Hautes-Alpes pres d'Abries, July 1875, Husnot, *Musc. Gall. 576* (WTU). Czechoslovakia: Mont. Leptovke, *Pilous 313,* Aug. 1947 (NY); Montes Vysoke Tatry, *Pilous 789,* Aug. 1948, as *P. decipiens* (NY). Sweden: Lapponica Tornensis, Bjornviken, *Jäderholm,* July 22, 1914 (NY). Norway: Kongswold, *Kindberg 279,* July 28, 1887 (NY). British Columbia, below Hector Mountain, *Macoun,* Aug. 13, 1890, type of *P. substriata* (NY); Wilmer District, Lake of Hanging Glaciers, *McFadden,* July 23, 1928 (CAN). Alberta: alpine meadow above Lake Agnes, 3 mi. by trail from Lake Louise, *Crum & Schofield 5341* (CAN). Quebec: Lac-au-Saumon, *Le Gallo 2863,* July 17, 1949 (IA); Gaspé Peninsula, Table Rock Mountain, *T. F. Collins,* Aug. 7, 1906 (NY). Labrador: Clearwater Lake, coll. *A. P. Low,* July 31, 1896, type of L. frigida (S-PA). Vermont: Mt. Mansfield, path to Ice Cave, *Lorenz 37,* July 6, 1906 (NY). Utah: Dagget Co., Spirit Lake, Uintah Mts., *Flowers 8197* (UT-F).

L. saxicola is a rock inhabiting species closely related to *L. striata.* It

differs in having leaves which are toothed, papillose and often falcate. The peristome resembles that of *L. striata* but is less well developed.

Although specimens cited by Limpricht (1895) for his *P. decipiens* were not available for study, it seems clear that his species is *L. saxicola* for the following reasons; his description except in respect to the peristome and the shape of the capsule fits *L. saxicola* perfectly; *L. saxicola* is common in the regions where Limpricht reports *P. decipiens;* many specimens have been determined by various bryologists as *P. decipiens* but they are all sterile and in vegetative structure they cannot be distinguished from *L. saxicola.*

A study of the type of Kindberg's *L. frigida* shows that it is a small specimen of *L. saxicola,* a species which is quite variable in size, with many European specimens as small as the American ones.

In 1900 Best described *P. substriata* as having few paraphyllia but the type which he named, Macoun, Aug. 13, 1890, has many paraphyllia. Best cited another specimen under *P. substriata,* the collection made May 21, 1898 by Williams at Lake Lindeman. This moss is without paraphyllia and should be referred to *L. iliamniana.*

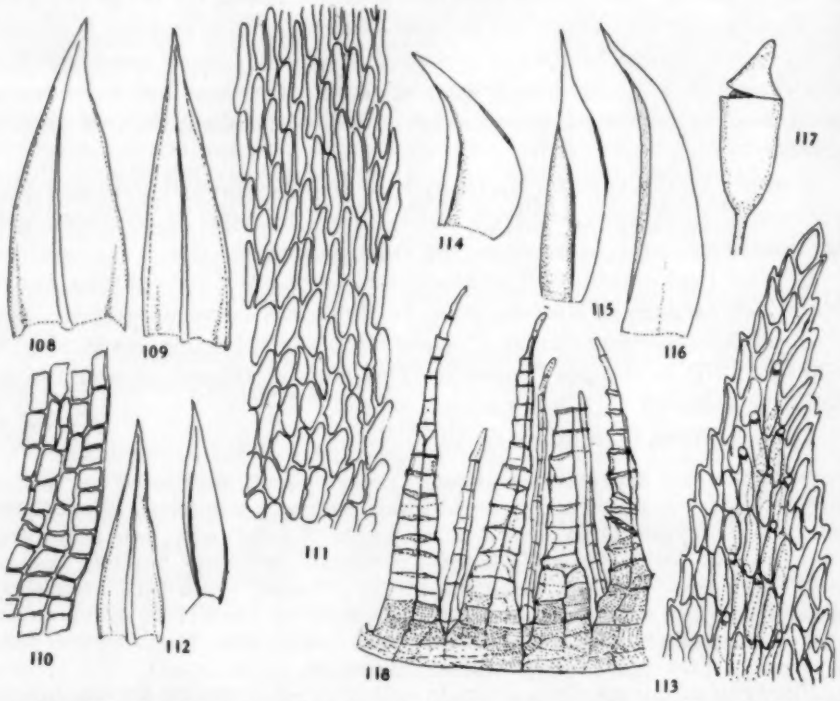
11. **Lescuraea iliamniana** sp. nov.

Plantae laxe depresso-caespitosae; colore viridi vergentes in fuscum-aureum. Caules prostrati, irregulariter ramosi, radiculosi. Paraphyllia nulla. Folia symmetrica, 1–1.2 mm. longa, 0.3–0.4 mm. lata; margines recurvi, costa valida; cellulae alares quadratae, medianae anguste lineares, 30–50 μ longa, 5–7 μ lata, basilares 16–40 μ longa, 7–8 μ lata. Dioica, antheridia ignota; seta 8–10 mm. longa; calyptra cucullata; theca erecta, symmetrica; externi dentes lamellosi, basi confluentes, interni processibus filiformibus brevibus e membrana angustissima.

Plants in thin mats, from green to yellow green or yellow brown, branching irregularly with the branches usually straight at ends, rarely curved; brown rhizoids in tufts; paraphyllia none or a very few small ones sometimes present where branches originate. Stem leaves straight and symmetric or nearly so, abruptly acuminate to a fine point or more often gradually acuminate to a somewhat blunt apex, plicate, decurrent, 1–1.2 × 0.3–0.4 mm.; margin entire or minutely serrulate at apex, strongly recurved nearly to apex; midrib prominent, usually ending just below apex; alar cells quadrate; median cells long and narrow, 30–50 × 5–7 μ; basal cells somewhat shorter and broader than median, mostly 16–40 × 7–8 μ, the walls often thick and pitted. Branch leaves gradually acuminate, smaller than stem leaves, serrulate at apex, midrib nearly percurrent or ending below apex. Small papillae formed by projecting cell ends present on back of midrib at tips of branch leaves and on upper lamina.

Dioicous, antheridia not found; archegonia on main stems with filamentous paraphyses; inner perichaetial bracts 1.4–1.6 mm. long, less abruptly acuminate than in most species of the genus, the midrib weak or wanting; seta 8–10 mm. long; capsules brown, erect and symmetric, the urn 1.2–1.4 × 0.55 mm.; operculum conic, calyptra cucullate, about 2 mm.

long, falling early; outer peristome yellow, teeth with lamellae and fine horizontal lines on basal joints, united at base to form a narrow, dark brown band 2–3 joints wide; endostome with narrow basal membrane; segments narrow, not keeled, a little shorter than the teeth, not papillose; cilia wanting, spores 13–16 μ (figs. 108–118).



FIGS. 108–118. *Lescuraea iliamniana*, Thomas s.n. type. FIGS. 108 and 109. Stem leaves. × 38. FIG. 110. Alar cells of stem leaf. × 360. FIG. 111. Basal, transitional and median cells of stem leaf. × 360. FIG. 112. Branch leaves. × 38. FIG. 113. Apical cells of branch leaf showing toothed margin and papillae on midrib. × 360. FIGS. 114–116. Perichaetial leaves from outer to inner. × 38. FIG. 117. Capsule × 14. FIG. 118. Part of peristome. × 175.

Type: Alaska, Thomas s.n. (LAWTON).

On rocks in Alaska and British Columbia.

Specimens examined:—Alaska: Iliamna Bay, southeast of Anchorage, on rock, *Rhoda Thomas*, Sept. 5, 1952 (LAWTON); Aleutian Islands, vicinity of Holz Bay, Moore Ridge, *Margaret B. Howard 722*, Nov. 11, 1945 (US, MICH). British Columbia: Upper Yukon River District, shore of Lake Lindeman, on rock, *Williams 557*, May 21, 1898, cited by Best as *P. substriata* (NY).

This species differs from *L. striata* and *L. saxicola* in having few paraphyllia or none and in the structure of the peristome; the segments are

nearly as long as the teeth, the teeth have lamellae and the band of the exostome is quite dark in color. It resembles the other species of the subgenus *Lescuraea* very closely in the cell structure of the leaves. The Japanese species, *L. julacea* Besch. & Card. (Cardot, 1911), lacks paraphyllia and is so close to this species in the structure of the gametophyte that no distinguishing characters have been found, but the structure of the outer peristome is quite different. *L. iliamniana* has yellow teeth with well developed lamellae and a dark basal band while *L. julacea* has brown or yellow brown teeth without lamellae and with conspicuous fine horizontal lines on the basal joints and vertical lines above.

EXCLUDED AND DOUBTFUL NAMES

Lesquereuxia glacialis Amann, Bull. Murithienne 40: 53. 1916–1918. Publication and specimen not seen. According to Amann in 1933, Loeske identified this moss as a form of *P. radicosa*. In 1927 Moenkemeyer stated that it was probably a form of *L. saxicola*.

Pseudoleskea arizonae Williams, Bryologist 33: 20–21. 1930. This moss should be called **Pseudoleskeella arizonae** (Williams) comb. nov.

Pseudoleskea atrovirens Dicks. Pl. Crypt. Br. f. 2: 10. 1790. Discussed under *L. patens*.

Pseudoleskea atrovirens subsp. *tenella* Kindb. Eur. & N. Am. Bryin. 50. 1896. found in Canada by Waghorne. Kindberg's specimen not seen. In 1900 Best made this a synonym of *L. patens*.

Pseudoleskea atrovirens var. *brachyclados* (Schwaegr.) B.S.G. Discussed under *L. saviana*.

Pseudoleskea brachyclados subsp. *borealis* Kindb. Can. Rec. Sci. 6: 20. 1894; Kindb. Eur. & N. Am. Bryin. 50. 1896. No specimens under this name were seen.

Pseudoleskea Artariae Thér. Revue Bryol. 25: 11–13. 1898. = *Pseudoleskeopsis Artariae* (Thér.) Thér. Ann. Crypt. Exot. 2: 1–22. 1929.

Pseudoleskea falcicuspis C. Müll. & Kindb. in Macoun, Cat. Can. Pl. 6: 182. 1892. The three specimens cited by Macoun under this name were examined and they are all *L. incurvata* and the name probably should be considered a synonym of *L. incurvata;* however, other envelopes from the Kindberg herbrium under the name *P. falcicuspis* contain *L. patens, L. incurvata* and *L. radicosa*.

Pseudoleskea pallida var. *filescens* Best, Bull. Torrey Club 27: 228. 1900. This variety is very close to or identical with *Leskea catenulata* var. *acuminata* Culmann, Revue Bryol. 40: 50. 1913. In 1953 Crundwell discussed this variety and the question of whether it should be considered a variety or a species. The species *catenulata* is now assigned to the genus *Pseudoleskeella* by many bryologists. Because Best's name precedes that of Culmann,

the name of the plant is **Pseudoleskeella catenulata** var. **filescens** (Best) comb. nov.

Pseudoleskea rigescens Lindb. Acta Soc. Fenn. 10: 247–248. 1872. Lindberg's description was based on Drummond, Musci Am. 225, a mixed packet. This name is discussed under *L. stenophylla.*

Pseudoleskea subfalcata Schimp. in herb. Lorentz, a synonym of *L. saxicola,* teste Milde (nomen nudum).

Pseudoleskea ticinensis Bottini, Proc. verb. Soc. Toscana Sci. nat. 18, gennajo 1891. Publication not seen. Braithwaite (1900) and Limpricht (1895) make this a synonym of *L. patens.*

Ptychodium affine Limpr. Die Laubm. 2: 802. 1895. This was described as without paraphyllia and according to Moenkemeyer (1927) it is *Brachythecium salebrosum.*

The following species described by Amann were transferred by their author in 1933 as indicated below:

Ptychodium trisulcatum Amann, Flore Mousses Suisse 2: 299. 1918.

Ptychodium pallescens Amann, Bull. Soc. Murithienne 40: 55. 1916–18.

Ptychodium abbreviatum Amann, Bull. Soc. Murithienne 40: 56. 1916–18.

Ptychodium albidum Amann, Bull. Soc. Murithienne 40: 56. 1916–18.

In 1933 Amann indicated that *P. albidum* and *P. trisulcatum* belong to the genus *Brachythecium,* that *P. pallescens* is a form of *P. radicosa* and that *P. abbreviatum* is a form of *L. saxicola.*

SUMMARY

1. *Lescuraea, Pseudoleskea* and *Ptychodium* are united and the species are described under the genus name *Lescuraea.*

2. The eleven species found in Europe and North America are described and illustrated.

3. Two new taxa are described, *Lescuraea iliamniana* from Iliamna Bay, Alaska and *Lescuraea incurvata* var. *gigantea* from the Olympic Mountains in Washington.

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SOME CYTOLOGICAL EFFECTS OF GIBBERELLIN[1,2]

C. A. BERGER

The many interesting physiological effects of gibberellin on plant growth have prompted this study of its cytological effects. The few previous studies of a cytological nature (Wada 1949, Kato 1955, Sachs & Lang 1957) have established cell elongation as the chief cause of rapid shoot growth and have indicated the possibility of an increased rate of mitosis in meristematic but not in fully differentiated tissues. These studies did not reveal any effects of gibberellin on the chromosomes or on the process of mitosis.

Material and methods. Roots of *Allium cepa* were immersed in solutions of gibberellin[3] of various concentrations for definite periods. Some were fixed immediately and others after definite periods of recovery in tap water. It was found that the most pronounced effects were obtained following 96 hours of treatment with a .01% solution and no period of recovery. Similar effects were obtained by shorter periods of treatment, 5 to 12 hours, followed by longer periods of recovery, 3 to 4 days. Aceto-orcein smear preparations were made in all cases.

Observations and results. Roots treated with gibberellin were never found to contain cells undergoing c-mitosis. The mitotic spindle is not destroyed nor is its formation during prophase inhibited. C-metaphase chromosomes are not formed and polyploidy does not result from this treatment.

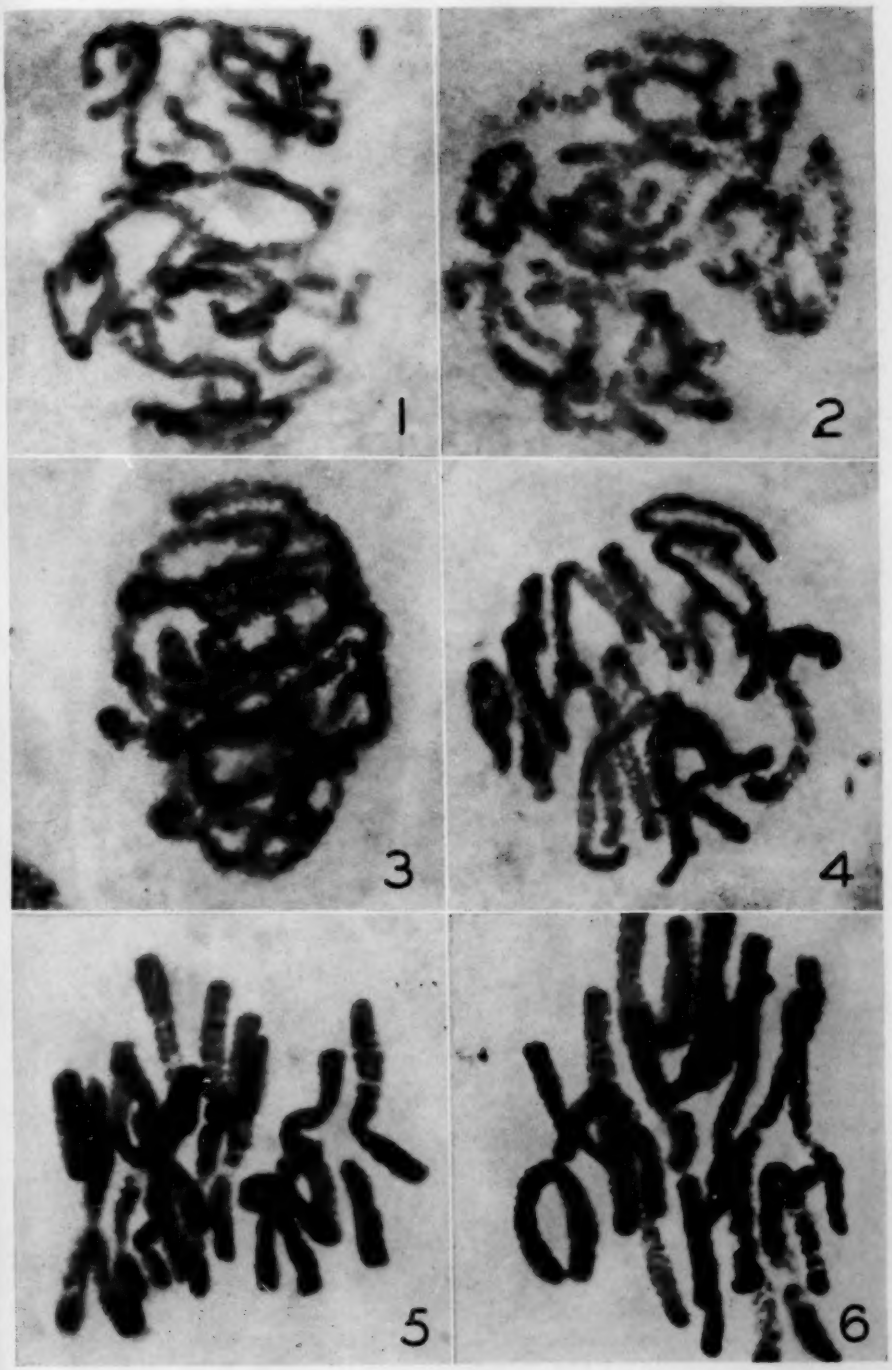
Unlike many growth promoting substances such as alpha-naphthalene acetic acid, gibberellin does not stimulate resting differentiated cells to enter mitosis. There is, however, some evidence that the rate of division may be increased in meristematic cells (Kato 1955, Sachs & Lang 1957).

Gibberellin, in any sub-lethal concentration, does not interfere with the process of mitosis and cell division is completed in its presence. Notable changes occur in the appearance of the chromosomes at prophase (figs. 1 to 4) and anaphase (figs. 13, 14) and especially at metaphase (figs. 5 to 12). Phrophase chromosomes are larger than in untreated material and their spiral structure is more evident (figs. 1 to 4). In late prophase (fig. 4) the chromatids are clearly separated from each other. A similar condition exists at anaphase (fig. 13).

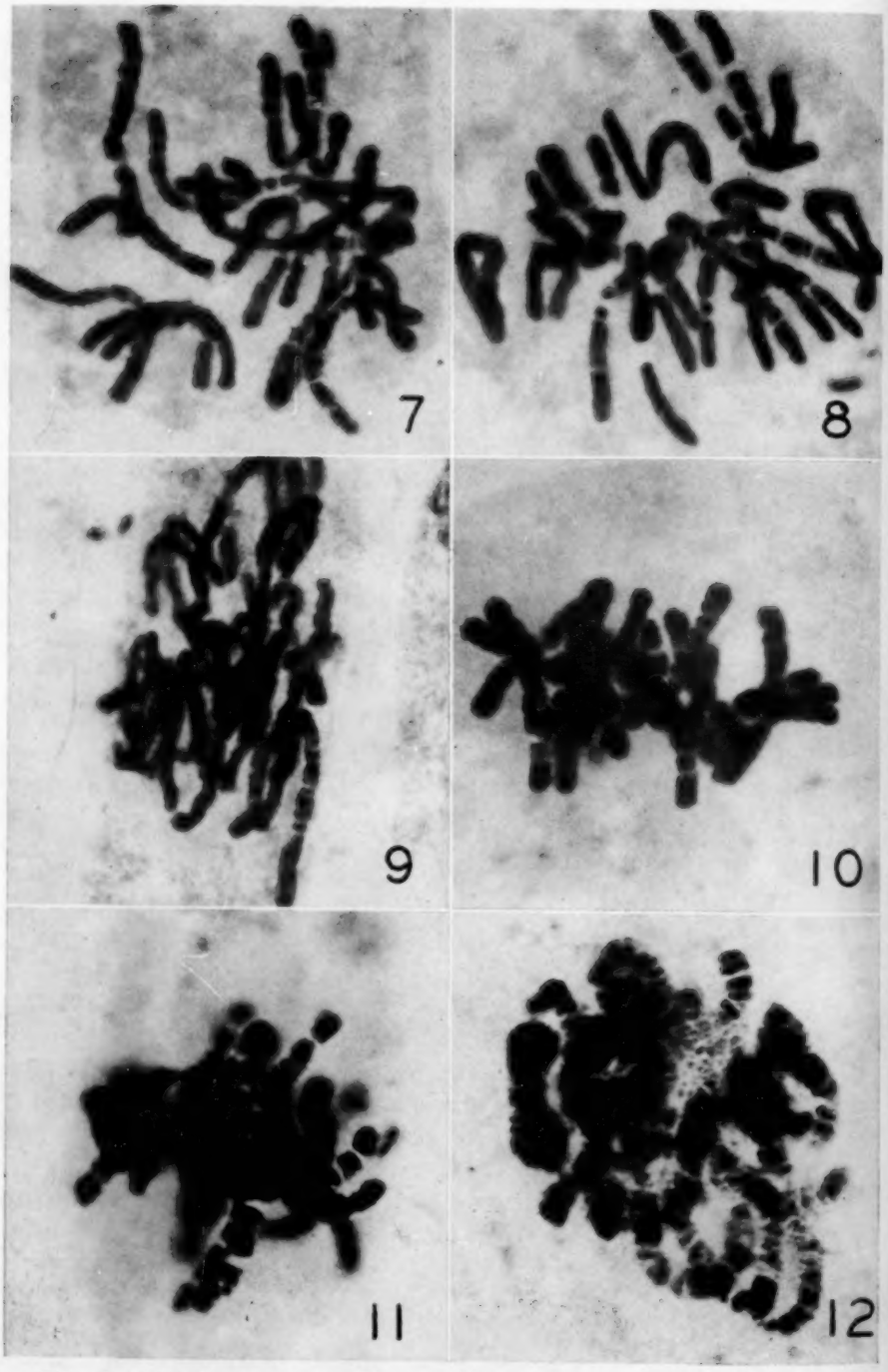
[1] This investigation was aided by a Grant (G2235) from the National Science Foundation.

[2] Illustrations published with the assistance of the Lucien M. Underwood Memorial Fund.

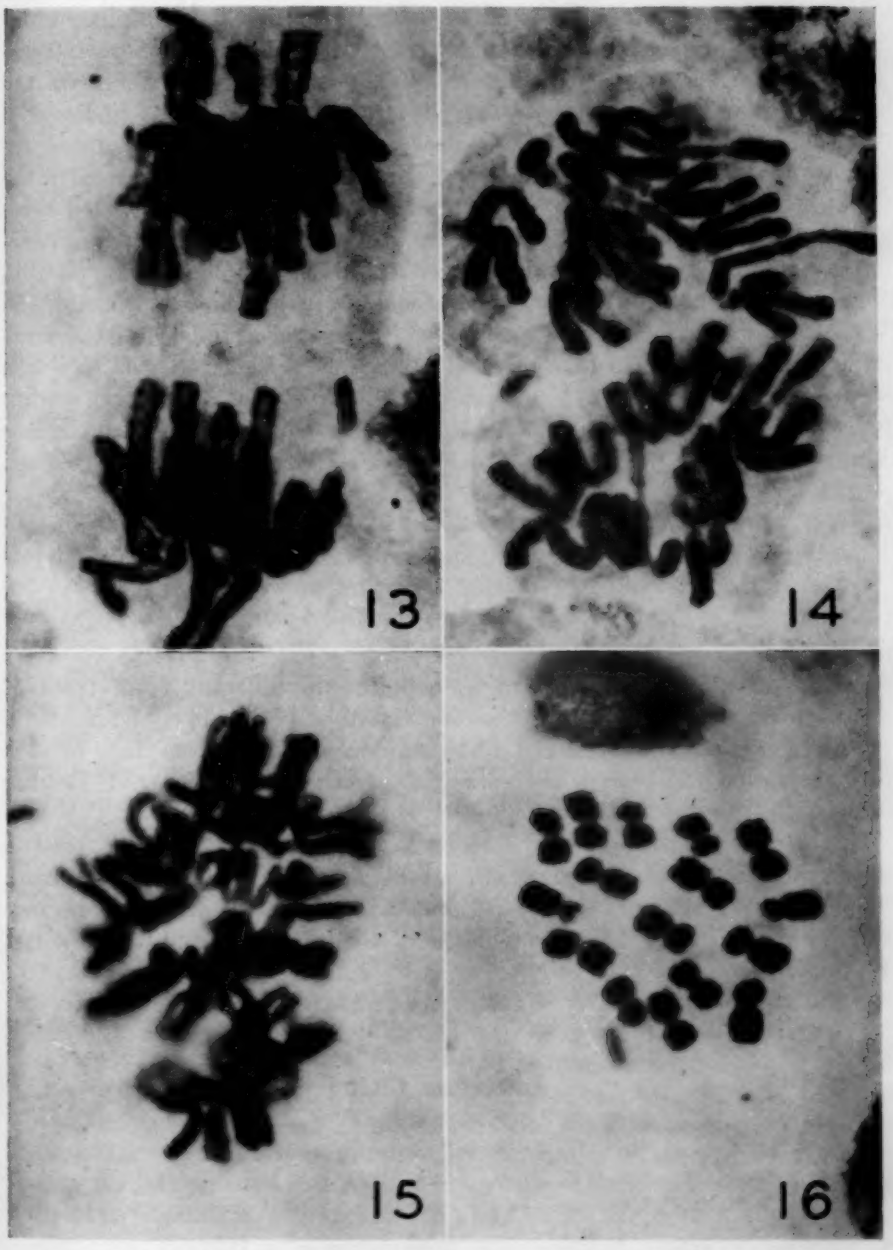
[3] The gibberellin used in this study was kindly supplied by Merck Sharp & Dohme; Chas. Pfizer & Co. and the U. S. D. A. Northern Utilization Research Division, Peoria, Illinois.



FIGS. 1–6. Photomicrographs of aceto-orcein smear preparations of roots of *Allium cepa* treated with gibberellin. Magnification × 1750. FIGS. 1–4. Prophase stages. FIGS. 5 & 6. Metaphases showing transition from spiral to banded condition.



FIGS. 7–12. Photomicrographs of aceto-orcein smear preparations of roots of *Allium cepa* treated with gibberellin. Magnification × 1750. Metaphase stages with segmented and banded chromosomes resembling the salivary gland chromosomes of the Diptera.



FIGS. 13–16. Photomicrographs of aceto-orcein smear preparations of roots of *Allium cepa* treated with gibberellin. Magnification ×1750. FIGS. 13 & 14. Anaphase stages. FIG. 15. Tetraploid metaphase. FIG. 16. Metaphase with supercontracted chromosomes.

The most striking effect noted was the assumption by metaphase chromosomes of a segmented appearance (figs. 8, 10 & 11) and in more extreme cases of a banded structure (figs. 7, 9 & 12) similar to that found in the salivary gland chromosomes of the Diptera. In some cases as in figure 5 some of the chromosomes show a clear spiral structure while others are beginning to show the segmented and banded appearance. Apparently the treatment causes the matrix of the chromosome to swell and the coiled chromonema to break at many points giving rise first to the segmented appearance and finally to the banded condition which can be clearly seen in figures 9 and 12. The thinner bands probably represent single gyres of the spiral while the thicker ones may represent several gyres, in all cases the clear spaces between bands represent breaks in the chromonema since it is possible to focus completely through the chromosome in these regions without encountering a chromonema. Cells with banded metaphase chromosomes are able to complete their division as anaphases are found with banded chromosomes (fig. 14).

Very rarely metaphases with supercontracted chromosomes are found (fig. 16) and an occasional tetraploid metaphase is seen (fig. 15). These two conditions are probably not related to treatment with gibberellin.

SUMMARY

1. The cytological effects of gibberellin are different from those of colchicine. There is no c-mitosis nor induction of polyploidy.

2. The cytological effects of gibberellin are different from those of such growth promoting substances as alpha-naphthalene acetic acid. Resting differentiated cells are not stimulated to enter mitosis.

3. Under treatment with gibberellin prophase chromosomes show a clear spiral structure and their chromatids are separated from each other. Metaphase chromosomes assume a segmented and later a banded appearance that is similar to the banded structure of the salivary gland chromosomes of the Diptera.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 84, NO. 5, PP. 361–365 SEPTEMBER, 1957

EXTRA-OVULAR DEVELOPMENT OF EMBRYOS IN TWO GRASS SPECIES

WILLIAM H. P. EMERY AND WALTER V. BROWN

Development in angiosperms of the embryo sac, fertilization, and the subsequent growth of the embryo and endosperm characteristically occur entirely within the ovule. The prefertilization stages, in fact, are usually confined within the nucellus, but even in those species in which the nucellus is absorbed early by embryo sac growth, subsequent development is confined within the one or two integuments.

In *Melilotus alba, M. officinalis* (Cooper 1933) and *Phaseolus vulgaris* (Weinstein 1926) the nucellar epidermis at the apex of the ovule appears to be ruptured by the enlarging embryo sac. The apical portion of the embryo sac subsequently extends into the long micropylar canal, until more than one-third of it is in contact with integumentary tissue. All development is, however, within the integuments of the ovule.

In species of *Philadelphus* (Mauritzon 1933), *Thesium* (Schulle 1933), *Galium* (Fagerlind 1937), and *Utricularia* (Kausik 1938) the embryo sac extends completely through the micropyle and much of it comes to lie outside the integuments where it is in contact with the ovary wall or placenta. The protruded portion of these embryo sacs usually contains the egg apparatus but development of the zygote and endosperm subsequent to fertilization, if any, is within the integuments. In *Galium* the extruded embryo sacs are non-functional. In *Utricularia* the zygote grows back into the portion of the embryo sac that is enclosed by the integuments. There are no cases known to the authors of embryos developing outside the integuments except in the Loranthaceae, a family characterized by having no integuments nor ovules in the usual sense (Maheshwari 1950, p. 142).

The present paper describes two different developmental conditions observed in an embryological investigation of two South African grasses. In these two species there is an occasional development of the embryo and endosperm which takes place partially or wholly outside the integuments of the ovule.

Material for this study was provided by the Plant Introduction and Exploration Service from their station at Experiment, Ga. Seed of two South African grasses, *Fingerhuthia africana* Lehm. (Plant Introduction Service accession numbers P.I. 208134 and P.I. 207241) and *Digitaria valida* Stent. (P.I. 209176) were germinated and grown at Austin, Texas, during 1956. Identification of each collection has been verified by the use of Chippindall's "Grasses and Pastures of South Africa" (1955) and specimens of each accession have been deposited in the University of Texas Herbarium.

Pistils were dissected from the spikelets after fixation in Navashin's fluid, embedded, sectioned at 10 microns, and stained in Delafield's haematoxylin. Although the plants grew well in the grass nursery, it is not known whether the Texas environment may have been responsible for the unusual types of development reported here.

Digitaria valida. The type of extra-ovular development in this species is characterized by growth of the egg-apparatus end of the embryo sac into the ovary wall through the broad ovular attachment. In grasses there is no funiculus, the ovule is borne sessile on the ovary wall with an extensive parietal attachment. Among the 55 ovules of *D. valida* examined, only one was observed in which the embryo sac had grown through the attachment region and into the ovary wall (fig. 1). It is evident (fig. 1) that the egg apparatus in this particular case was well outside the ovule. Subsequent developmental stages were not available but it is probable that early embryo development and at least part of the more mature embryo would be located outside the remains of the ovule.

The growth of embryo sacs through the attachment and into the ovary wall, as in *D. valida*, has been previously noted in a few apomictic grasses. Snyder, Hernandez and Warmke (1955) reported the growth of aposporous embryo sacs of *Pennisetum ciliare* (L.) Link into the region of ovular attachment where they sometimes invade the tissues of the ovary wall. Emery (1956) noted the same type of development in the aposporous *Setaria villosissima* (Scribn. and Merr.) Schum.

Fingerhuthia africana. In this species extra-ovular development is of a different type. In about half of the ovules examined the epidermis at the apex of the nucellus degenerates. Furthermore, the development of the integuments is frequently irregular. It is typical for grasses to have the inner integument completely surround the nucellus and form the micropyle. The outer integument does not generally reach the micropylar region nor form any part of the micropyle. In *F. africana*, however, either the inner or the outer integument (fig. 3) may form the micropyle, or neither may do so. In those ovules in which a micropyle is formed sufficiently early, subsequent embryo sac development appears to be within the ovule even though the nucellar epidermis degenerates (figs. 2 & 4). It is probable that, if the nucellar epidermis degenerates before the integuments cover the nucellus or if the development of both integuments is delayed, the embryo sac may grow out of the ovule carrying the egg apparatus and polar nuclei into the ovary locule. Kausik (1938) reported that a similar slow growth of the integuments in *Utricularia coerulea* permitted the embryo sac to protrude from the ovule. Only 6 ovules of the more than 100 examined actually showed the embryo sac to have moved out of the ovule. However, most of the pistils were sectioned in early stages for developmental study.

Of the 12 older pistils, half had embryo sacs outside of the ovules. It is probable that extra ovular development is common in the two plants studied and perhaps in the species as a whole.

The egg-apparatus-containing part of the extruded embryo sac of *F.*

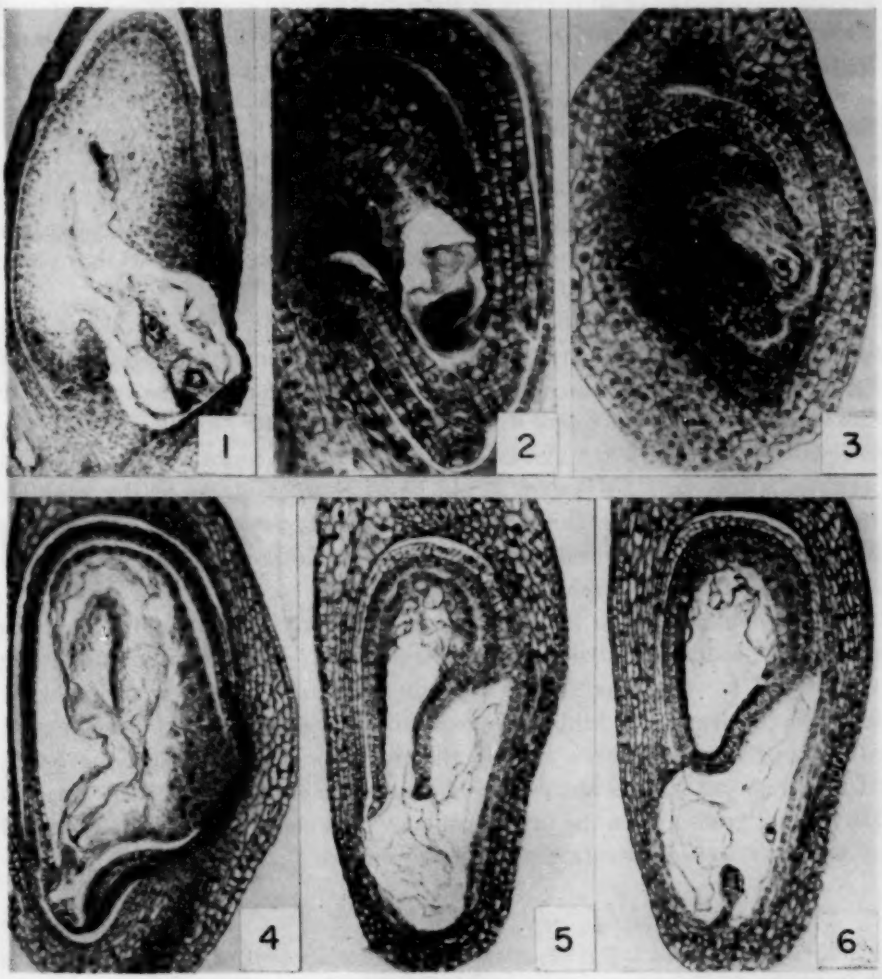

FIG. 1–6. Extra-ovular embryo sacs, eggs, and embryos. FIG. 1. Ovary of *Digitaria valida* showing the extra-ovular location of an egg. FIGS. 2–6. *Fingerhuthia africana.* FIG. 2. An ovule with an early degeneration of the nucellar epidermis. FIG. 3. An ovule with irregular development of the integuments. The inner integument is retarded and the outer integument forms the wide micropyle. FIG. 4. An ovule in which the embryo-sac entered the micropyle but later aborted. FIG. 5. An ovary showing the vacated ovule in the upper portion of the ovary cavity. FIG. 6. Another section through the same ovary shown in figure 5. The proembryo is attached to the ovary wall. An endosperm nucleus lies just to the right of the proembryo.

africana lies in a cavity formed by the lower part of the ovarian locule. In the normal grass ovary such a cavity is not formed, for, as the ovary wall increases in length, the ovule also increases in length. In ovaries containing extruded embryo sacs, however, growth of the ovule appears inhibited whereas the basal portion of the ovary wall adjacent to the functional embryo sac enlarges rapidly. As a result the empty ovule is carried upward by the increasing length of the ovary wall (fig. 5). At the same time a cavity is produced in the basal region of the ovary. Most of the embryo sac lies in this cavity where it appears that fertilization and the subsequent development of the endosperm and embryo takes place (fig. 6). It is apparent that growth of the ovule is dependent upon continued growth of the embryo sac within it and that if the ovule contains no embryo sac the ovule does not grow. In this type of development there is no likelihood of the embryo ever getting back inside the ovule.

It is not likely that the passage of food into an extra-ovular grass embryo sac would be essentially more difficult than into an embryo sac lying within the integuments. In grass ovaries, food and water enter the embryo sac across the parenchyma tissue separating the vascular bundle in the ovary wall from the embryo sac. An embryo sac in direct contact with the ovary wall, as is true in *F. africana*, would be as close or closer to the vascular supply than one lying within the ovule. The embryo sac of *D. valida* lying in part within the ovary wall would certainly be closer to the vascular supply than would an embryo sac within an ovule.

Extra-ovular embryo development is not likely in plants in which the mature reproductive structures are seeds and dehiscent fruits. In the Gramineae, however, the mature reproductive unit is a caryopsis (achene) in which the ovary wall functions essentially as a seed coat. The development of endosperm and embryo outside the integuments but within the locule of the grass ovary does not result in a greatly modified structure, since in the normal grass grains the integuments or seed coats are nearly eliminated at maturity by degeneration and absorption.

SUMMARY

1. Two different types of extra-ovular development of eggs and embryos in grasses are reported in two species of South African grasses.

2. In one pistil of *Digitaria valida* the part of the embryo sac containing the egg apparatus had grown nearly through the ovary wall (fig. 1).

3. In a number of pistils of *Fingerhuthia africana* the embryo sac had grown out of the ovule into the ovarian locule where a cavity was formed containing most of the embryo sac (fig. 6). Further development progressed at least as far as the early endosperm and proembryo stage (fig. 6).

4. In grasses, at least, there seems to be nothing to prevent such extra-ovular development from leading to mature and nearly normal grains.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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DECOMPOSITION OF MARSH GRASS BY AEROBIC MARINE BACTERIA[1]

PAUL R. BURKHOLDER AND GEORGE H. BORNSIDE

Studies on biological productivity in the marsh areas of coastal Georgia have indicated the importance of the marsh grass, *Spartina alterniflora* Loisel., for primary synthesis of organic matter, which becomes available for use by numerous kinds of plants and animals living on the marsh lands and in the estuarine waters of the region. In an earlier paper (Burkholder 1956) it has been shown that the general nutritive properties of marsh grass, as revealed by proximate analyses, are not unlike those of Coastal Bermuda grass, which is an excellent pasture plant. It appears that the residues from each annual crop of marsh grass are transformed by microbial action into materials more readily available to the larger fauna and flora. The purpose of this paper is to demonstrate some of the phenomena connected with aerobic decomposition of marsh grass by marine bacteria in the region of Sapelo Island, Georgia.

Decomposition of grass. The decomposition of *Spartina* was studied both in nature and under laboratory conditions with mixed cultures of bacteria collected from marshes and marine waters. To demonstrate microbial decomposition of *Spartina* in nature, shoots of fresh green grass were cut at the mud level on November 28, 1955, and placed in specially constructed lath crates, which were then submerged in the shallow water of the Duplin River. These crates were constructed out of cypress lath, fastened by means of galvanized nails, to form boxes measuring about $18'' \times 18'' \times 36''$ in size. Ten pounds of green grass were weighed into each of twelve crates. The calculated initial dry weight was 1550 grams per crate. At different times afterward, the residual dry matter was determined by removing crates, washing the grass contents gently with a stream of fresh water, and allowing the remaining material to air-dry in a warm room. The results obtained for decomposition of grass during the period November 28, 1955–September 19, 1956 are shown in figure 1. Residues are plotted as per cent of the initial dry matter present at the start of the experiment. It appears that decomposition takes place slowly during the relatively cold winter and more rapidly in the spring and summer. Numerous small shrimp were found to be present in the decomposing grass during

[1] These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Georgia, NR 163 308. Some of the work was done at the Marine Biology Laboratory on Sapelo Island, Georgia, and at the Brooklyn Botanic Garden, Brooklyn, New York.

the early spring months. These disappeared in late spring. By June 3, the leaves had become almost completely disintegrated, leaving behind only hard stems. These resemble the great masses of old *Spartina* stems, from the preceding year, which drift on shoals, and are seen in abundance during the summer months along the coast of Georgia. Apparently the relatively soft leaves succumb first to enzymatic activities of the numerous bacteria

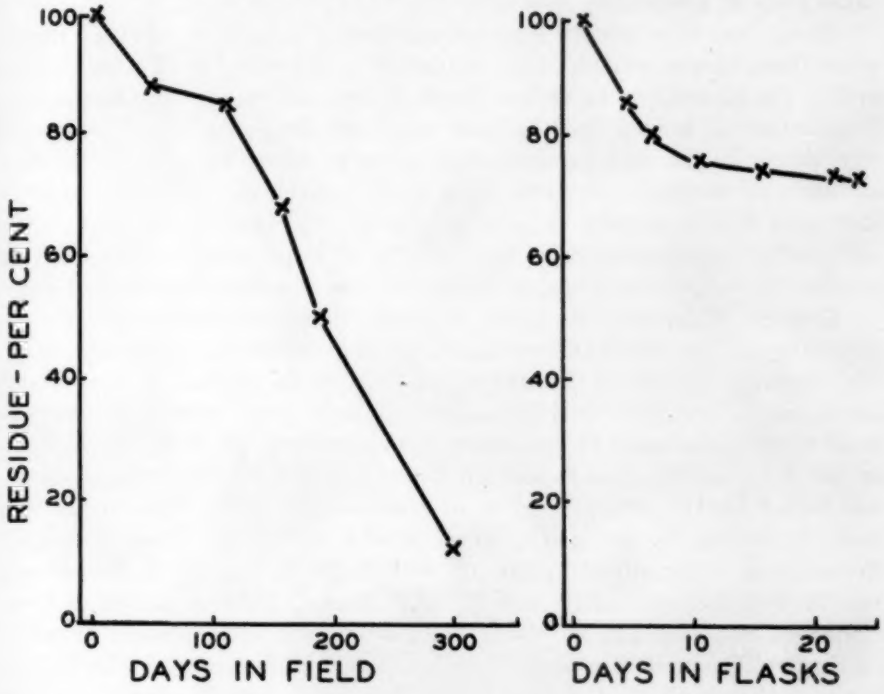

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FIG. 1. Decomposition of marsh grass in sea water, expressed as per cent of initial dry weight of grass after different periods of time. Left, dry residue remaining in crates, placed in the Duplin River, during period November 28, 1955–September 19, 1956. Right, residues in flasks inoculated with marine mud bacteria and shaken at 30° C for 24 days.

and other microbes, and later the cellulose and lignin of the stems are disintegrated.

Loss in dry weight of mature dried grass was also studied during a period of incubation in flasks rotated on a shaker at 30° in the laboratory. The grass was ground in a Wiley mill, and 2 grams were placed in 50 ml. of sea water in each of a series of 250 ml. flasks. The grass samples were inoculated with 1 ml. of a mixture of bacteria obtained from a suspension of marsh mud in sea water. As blanks, tared flasks, each containing 51 ml. of sea

water, were dried at 100° C, cooled in a desiccator, and weighed on an analytical balance. At different intervals of time, the experimental flasks were dried and weighed in a similar way. All samples were determined in triplicate. The dry residue, calculated as per cent of the initial dry weight, is shown for different times in figure 1. The graph indicates that loss in dry matter is rapid during the first 10 days, after which further decomposition takes place at a relatively slow rate.

These two experiments demonstrate that a certain portion of marsh grass disintegrates readily when subjected to microbial action, in the sea and in the laboratory. In nature, losses of dry matter occur by mechanical fragmentation, animal feeding, and microbial decomposition. The loss of dry weight in the shaking flask experiment probably takes place through diffusion of metabolic products, such as CO_2, NH_3, H_2, and other volatile materials. It is of interest to note that, in nature, about 50 per cent of the dry matter disappeared from the samples of grass after a period of six months. In the shaking flasks, a 25 per cent loss was observed after 21 days.

Growth of bacteria in grass extracts. Numerous isolates of aerobic heterotrophs were obtained from marsh mud, decomposing grass, and estuarine water, by streaking the source materials on the surface of agar plates containing either Difco nutrient agar, 5 per cent grass extract, or mud extract agar media made in sea water, with a salinity of about $30^{o/oo}$. Each of 125 such isolates, maintained on Difco nutrient sea water agar slants, was tested for the ability to grow in grass-extract broth. The extract was made by boiling 5.0 gm. of dry grass powder in 100 ml. of sea water for five minutes. After adjusting the pH with NaOH to 6.8, the brown extract was filtered through Celite on a Buchner funnel. Fifteen milliliters were dispensed into each 125 ml. flask. Sterilization was accomplished by autoclaving at 15 pounds pressure for 15 minutes. Cultures were incubated on a rotary shaker at 30° C for 48 hours. Preliminary studies indicated that three fourths of the cultures grew in grass extract medium. In fact, thirty five per cent of the isolates grew better in grass extract medium than in Difco nutrient broth made in sea water. When all of these isolates were tested for their ability to grow in Difco nutrient broth, made in sea water and also in distilled water, 72 per cent grew in sea water broth, but not in standard nutrient broth. Many of the isolates appear to be marine bacteria with respect to their requirement for sea water as a diluent (ZoBell and Upham 1944). In the group of organisms tested, 13 isolates were able to grow in both sea water broth and in standard nutrient broth. Two of these grew very well in grass extract medium.

Standard bacteriological procedures were used for the identification of a collection of twenty aerobic, heterotrophic isolates, which were employed in various experiments. Some of the isolates grew only in sea water media;

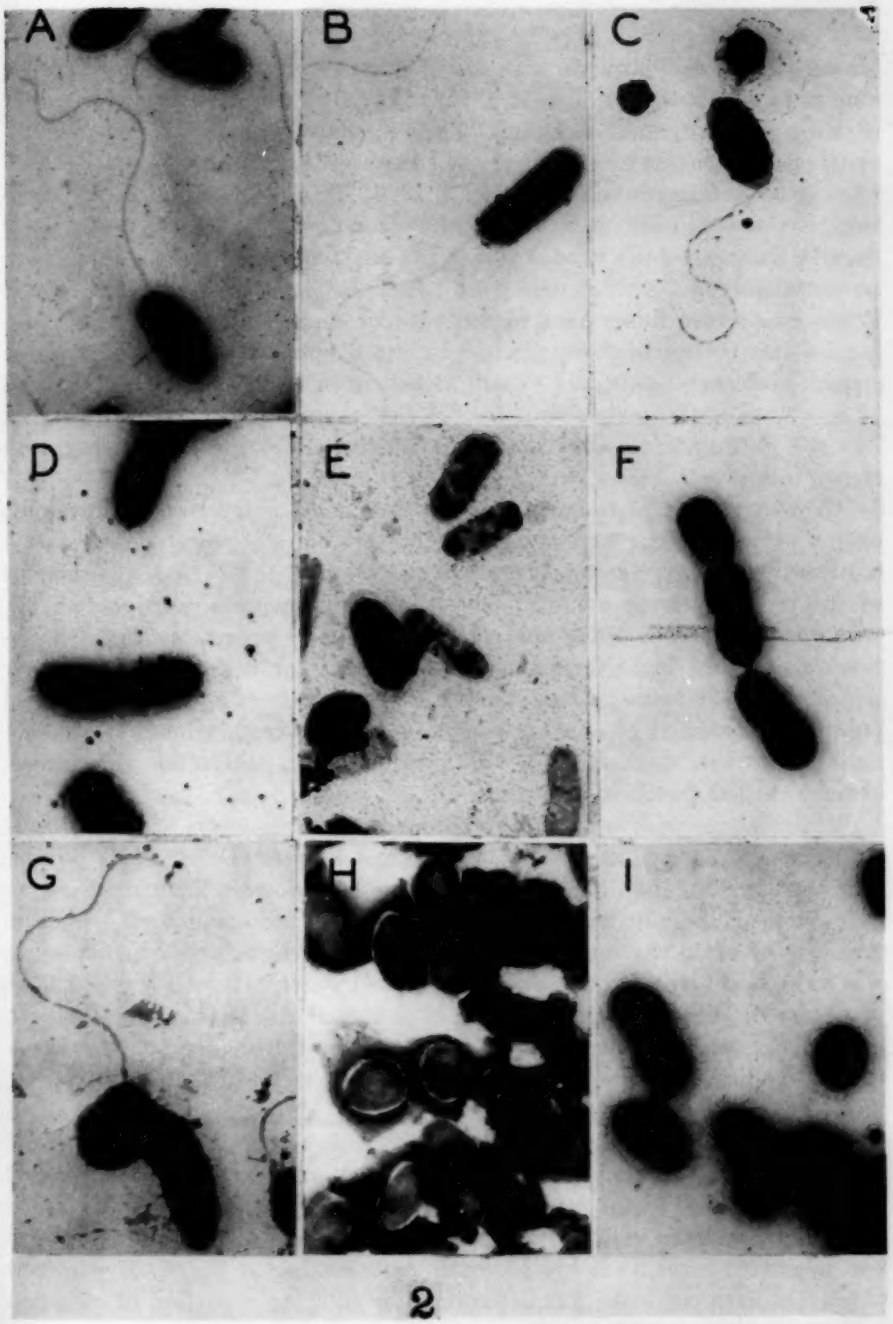

FIG. 2. Electronmicrographs (×9,000) of some representative bacteria isolated from mud and estuarine waters in the vicinity of Sapelo Island, Georgia. Photos A and B show cells of culture 20, isolated from grass enrichment of marsh mud. Photo C is isolate 28, a single-flagellated rod, obtained from marsh mud. Photo D illustrates isolate 10 with a thin capsule. E, isolate 8, is a red *Serratia* from the Duplin river. F. shows a slime layer around dividing cells of the mud isolate 19. G and H illustrate number 7, a motile rod. I, shows a thin capsule about the cells of isolate 1.

others grew in media made with distilled water or with sea water. Twelve marine types (1, 2, 3, 4, 5, 6, 7, 8, 15, 16, 17, 18) were Gram-negative rods of varying length and thickness. They appeared somewhat pleomorphic, ranging from chains and filaments to coccobacillary forms. Of similar morphology were the euryhaline isolates 9, 19, 10, 20 and 11. All of these Gram-negative, non-sporing rods were either non-motile or motile with polar flagella. They generally produced acid in glucose broth, and the majority can be tentatively assigned to the genus *Pseudomonas*. Cultures 1, 2, and 5 produced a green fluorescent pigment under some conditions. The remaining isolates belong in three genera. Isolate 8 appears to be a red, marine species of *Serratia*. Cultures 14 and 21 belong in the genus *Aerobacter*, and 22 is a species of *Flavobacterium*. The last three isolates were euryhaline. The morphology of several isolates is illustrated by electron-micrographs shown in figure 2.

Growth of several isolates in 5 per cent grass extract was determined over a period of time by growing the bacteria in stationary screw-capped culture tubes, or in Ryan flasks on a rotary shaker at 25° C. Measurements of the turbidity were made at 620 mμ in a Coleman spectrophotometer, with corrections to exclude absorption by the pale brown medium. In stationary cultures, logarithmic growth proceeded for different isolates over periods of 10–20 hours, with apparent generation times of 3–6 hours. Final population densities of about $1.4 - 6.2 \times 10^9$ cells were attained. In shaking cultures growth was generally more rapid, with generation times from about 60 to 150 minutes.

Experiments were set up to determine growth responses of typical mud bacteria in different concentrations of grass extract. Dried grass powder was extracted in distilled water and also in sea water. By evaporating samples to dryness, it was possible to determine the amount of grass materials present in the nutrient media. Double strength artificial sea water was used as diluent for the series of distilled water extracts, to yield a set of five media containing from 75 to 1200 mg. of dry matter per 1000 ml. of artificial sea water medium. The artificial sea water (Lyman and Fleming 1940) has the following composition in g/kg: NaCl, 23.48; Na_2SO_4, 392; $NaHCO_3$, 0.19; KCl, 0.67; KBr, 0.10; $MgCl_2$, 4.98; $CaCl_2$, 1.10; $SrCl_2$, 0.02; H_3BO_3, 0.03. A similar series was set up also with artificial sea water as diluent for the sea water extracts. All media were dispensed into Ryan flasks (15 ml. per flask), sterilized by autoclaving in the usual way, and inoculated with actively growing bacteria. The turbidity of growth was measured after 48 hours of continuous shaking at 25° C. Dry weight of washed bacterial cells, was determined by filtering a portion of each culture through tared Millipore filters, drying in an oven at 100° C, and weighing the dried bacteria and filters. Five ml. of distilled water were used to

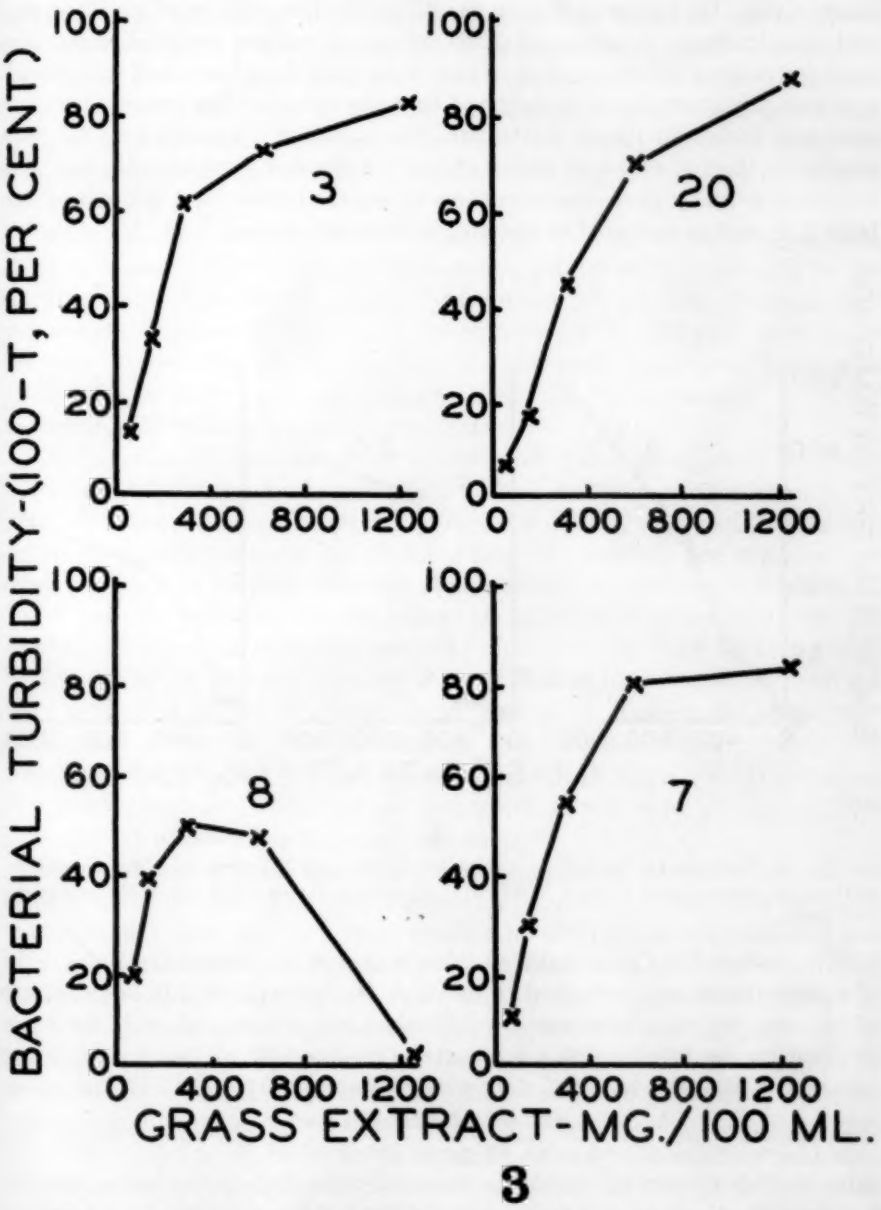

FIG. 3. Growth of four isolates in different concentrations of marsh grass extract in sea water. Note inhibition of the red *Serratia* (8) at the highest level of grass extractives.

wash rapidly the bacterial film on the filters for the purpose of avoiding any serious salt errors. A measured small volume of culture suspension was also used for making dilution series, which were plated and counted in a standard way, to determine the number of bacteria present. The essential growth data are shown in figure 3. Growth (as turbidity) appeared to be very similar in the two series of media except for the red *Serratia* (8), that was inhibited in the higher concentrations of grass extract. Best growth of isolates 3, 7, and 20 occurred at the higher levels of extract.

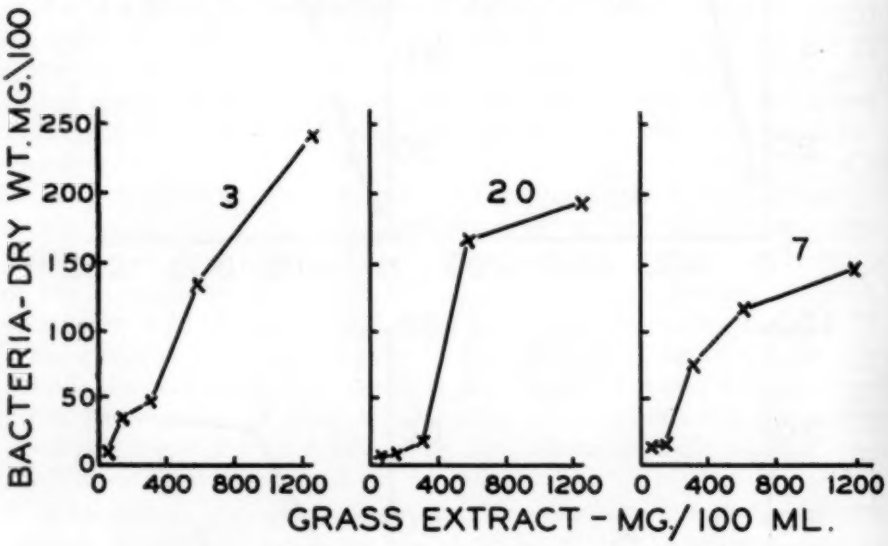

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FIG. 4. Dry weights of bacterial cultures 3, 20, and 7, grown in different concentrations of marsh grass extract. Growth yield averages about 0.2 for these organisms (see text).

The values for dry weight of three cultures, determined at each level of grass extract, are presented in figure 4. In this experiment the numbers of bacteria per ml., determined by dilution and plating, after 48 hours in the medium containing 600 mg of extractive per 100 ml., were as follows: isolate 3, 1.98×10^9; isolate 7, 1.28×10^9; isolate 20, 0.93×10^9. If one calculates growth yield, $K = \frac{\text{dry wt. of bacteria}}{\text{dry wt. of grass extracts}}$, at the higher levels, this value averages about 0.2 for these three bacteria. This value is appreciably less than the K calculated by Monod (1949) for other kinds of bacteria.

From the above data, it may be possible to estimate the dry weight of the annual crop of bacteria that grow on marsh in the natural environment, if one assumes that similar relationships exist in the laboratory and in

nature. From our earlier calculations (Burkholder 1956) it can be shown that approximately 56 per cent of marsh grass consists of protein and soluble extractives. If 0.2 of this is readily converted to bacterial substance, then $0.56 \times 0.2 = 0.112$ (or 11.2%) of the annual crop of marsh grass may be available for rapid production of bacterial substance. In addition to this, the conversion of crude fiber by cellulolytic organisms takes place more slowly.

From the data, it is possible to calculate the average number of bacteria, of three isolates, in the culture fluid as being 1400 million per ml., in the medium containing 600 mg. of grass extract per 100 ml. The corresponding dry weight of these bacteria comes to an average of 1320 μgm. per ml. of medium. Hence, the dry weight/number relationship of these bacteria is 1320/1400, or 0.940 μgm. per million cells. In a round number, then, 10^6 bacterial cells contain 1 μgm. of dry matter.

The number of heterotrophic, aerobic bacteria in samples of mud collected on October 26, 1955 from high, middle, and low marsh areas in the vicinity of Sapelo Island were determined by plating appropriate dilutions on Difco nutrient agar in sea water. About 10^7 bacteria per gram of wet mud were found in these samples. The number of bacteria, estimated in water samples taken at this time from six different beaches along the sea islands, averaged 18,000 cells per ml. of sea water. The highest count, 28,000 per ml., occurred in Doboy Sound. Counts of about 50,000 per ml. were estimated in Doboy Sound, in August 1955. Taking the value of 1 microgram of dry weight = 10^6 bacteria, it is possible to calculate the dry weight of the standing crop of bacteria. In marsh muds this is conservatively estimated at 10 micrograms per gram of wet mud, and about 0.05 μgm. per ml. of sea water in Doboy Sound.

Enrichment of mud extracts. In order to learn something about the conditions which would stimulate growth of aerobic heterotrophs in marsh mud, samples were collected from areas representing the three main types of marsh in the vicinity of Sapelo Island. Extracts were made by suspending 30 gm. of mud in 100 ml. of sea water, boiling for 5 minutes, and agitating for 5 minutes in a Waring blendor. The supernatant was clarified by centrifugation, and by final filtration through Millipore filters. Aliquots of this solution were supplemented with the addition of phosphate, dextrose, ammonium nitrate and dextrose, casein hydrolysate, or *Spartina* extract, in amounts shown in table 1. These media, along with mud extract as a control, were autoclaved in Ryan flasks, and then inoculated with a crude mixture of mud bacteria obtained by suspending mud from three marsh regions in aged sea water. After incubating for 48 hours at 25° C the turbidity of growth was determined at 620 mμ with a Coleman spectrophotometer (table 1).

TABLE 1. *Growth of bacteria in mud extract, and in mud extract supplemented with salts and organic materials. Data are expressed as turbidity (100-T) after 48 hours.*

Treatments	Mud Extract Only	Mud Extract + KH_2PO_4 0.05 gm/1.	Mud Extract + Grass 10%	Mud Extract + N–Z Case 1%	Mud Extract + NH_4NO_3 0.5 gm/1. Dextrose 1%	Mud Extract + Dextrose 1%
Source of Bacteria						
Low Marsh	7	9	96	97	18	17
Middle Marsh	5	6	97	97	44	14
High Marsh[2]	6	7	97	98	21	15

[2] This terminology of marsh types was defined in the paper by Burkholder (1956).

The data indicate clearly the growth promoting effects of casein hydrolysate and grass extract. The inability of mud extract alone to support growth suggests its spent nature. Apparently, organic nitrogen compounds, such as amino acids, greatly stimulate the growth of certain bacteria present in these muds. Preliminary studies on oxygen uptake of the organisms present in mud have been made in a Warburg respirometer. In the presence of added casein hydrolysate, respiration was greatly stimulated above the endogenous level, after one to two hours. Cell multiplication was likewise accelerated by casein amino acids.

TABLE 2. *Growth of nine pure cultures of marine bacteria in mud extract, and in enriched mud extract. Data are expressed as turbidity (100-T) after 48 hours.*

	Mud Extract Only	Mud Extract + N–Z Case 1%	Mud Extract + Grass 10%	Mud Extract + Dextrose 1%	Mud Extract + KH_2PO_4 0.05 gm/1.	Mud Extract + NH_4NO_3 0.5 gm/1.
Average turbidity	9	37	85	11	9	10
Range of turbidity	8–12	9–53	48–96	8–15	8–10	7–12

This experiment was followed by use of a similar series of media, prepared from mud extract and the supplements indicated above, into which nine pure cultures of mud bacteria were separately inoculated. The average and range of growth, as indicated by turbidity (100-T) measured after 48 hours, are shown in table 2. Here again, grass extract appears to supply necessary substrates for growth of mud organisms which do not respond to single enrichments of dextrose, phosphate, or ammonium nitrate.

In view of the stimulating effect of marsh grass upon growth of mud bacteria, a further study was made to determine the influence of adding dextrose, ammonium sulfate and casein hydrolysate to grass extract. Ten

pure cultures of representative mud bacteria were inoculated into the autoclaved media, contained in Ryan flasks, and allowed to grow for 48 hours at 25° C. The data are presented in table 3. Some organisms, such as 7 and 3, exhibit good growth in all media; certain isolates, such as 8, 23 and 16, grow poorly in grass extract, and show stimulation with added N-Z Case; still others, like 22, do not grow well in any of the media used. It is a significant fact that many bacterial isolates from water and mud are able to grow well on extracts of *Spartina* in sea water. Addition of N-Z Case to grass extract medium further stimulated growth of many isolates, but neither dextrose nor $(NH_4)_2SO_4$ showed any enhancement of growth in the amounts used as supplements. The inhibitory effects of dextrose suggested by the data of table 3 were studied further, and it was found that about 0.2

TABLE 3. *Growth of pure cultures of marine bacteria in grass extract, and in grass extract with added dextrose, $(NH_4)_2SO_4$, or N–Z Case. Data expressed as turbidity (100-T) after 48 hours.*

Treatments	Grass Extract 2.5% Solids	Grass Extract + 1% Dextrose	Grass Extract + 0.1% $(NH_4)_2SO_4$	Grass Extract + 0.1% N–Z Case
Organisms				
7	87	64	88	90
20	88	43	90	91
18	32	7	32	57
8	12	2	9	45
3	88	90	90	89
21	67	32	90	87
17	33	3	25	39
22	15	6	19	3
23	18	0	20	49
16	16	1	13	42

per cent of sugar is more favorable than 1.0 per cent for growth of these bacteria.

Nutritional studies on defined media. In view of the stimulating effect of grass extract and casein hydrolysate upon growth of these marine bacteria, it was of interest to investigate the influence of different compounds in chemically defined media. In a preliminary experiment, eleven cultures were investigated in media containing single amino acids added to a basal sea water medium made as follows: aged and filtered sea water, 1 liter; KH_2PO_4, 0.008 gm.; K_2HPO_4, 0.008 gm.; dextrose, 8.0 gm.; glycerol, 2.0 ml. In preparing this series, 150 mg. of each L-amino acid were dissolved in 150 ml. of medium, and the pH was adjusted to 6.8. Double the amount of each DL-amino acid was used in preparing stock solutions. Then 5 ml. of each of the 18 stock solutions were added together, to form a set of 19 single omission media, each one having 18 amino acids present with a different one of the 19 omitted from each final mixture. This gave a medium

containing 1 mg. of mixed amino acids per ml. In addition, all 19 amino acids were pooled together to make a "complete" mixture in the 20th medium.

A second set of media was also made, with single additions of each amino acid supplied at a level of 0.5 mg. per ml. of the basal sea water medium. Five ml. of each were dispensed in 18 mm. × 150 mm. culture tubes, and sterilized by autoclaving. One loopful of a bacterial suspension was used to obtain uniform inoculation of each tube in a series. After incubation for 72 hours at 25° C, growth was measured at 620 mμ in a Coleman spectrophotometer.

Appreciable growth occurred for all cultures supplied with the pooled 19 amino acids, the turbidity (100-T) ranging from 16 to 62. Omission of single amino acids from the mixture in nearly all instances failed to reduce growth. This indicated that these isolates do not have a specific requirement for single amino acids, although they grow better on sources of amino nitrogen than on an inorganic source, *e.g.*, $(NH_4)_2SO_4$. Growth on single amino acids, as the sole source of nitrogen, was generally less pronounced than in multiple mixtures. Various isolates attained a turbidity of 30 or more in solutions containing only arginine, glycine, alanine, proline, serine, aspartic acid, glutamic acid, cystine, or histidine. Growth was generally poor on the following compounds: tryptophan, valine, tyrosine, methionine, leucine, isoleucine, phenylalanine, cysteine, and threonine.

For further studies, twelve isolates were selected from a group of organisms that grew well on *Spartina* extracts in aged sea water, but showed variable responses in a synthetic sea water medium, to which the following were added together per liter—dextrose, 8.0 gm.; Na succinate, 2.0 gm.; glycerol, 2.0 gm. The composition of the synthetic basal medium is as follows: artificial sea water (composition as given earlier), 1 liter; $(NH_4)_2SO_4$, 1.0 gm.; KH_2PO_4, 0.008 gm.; K_2HPO_4, 0.008 gm. To the synthetic basal medium consisting of artificial sea water, ammonium sulfate and phosphate, various compounds were added in order to determine their growth promoting effects. Experimental treatments are indicated in table 4, along with the growth data obtained after incubation at 25° C for 72 hours. The results show that amino acids of casein provide for excellent growth, and that, among the mixtures of amino acids used, the combination of alanine, aspartic acid, and glutamic acid yields the best growth. These three compounds are not well utilized, however, when added singly, and neither are the other groups of amino acids. Similar data have been reported by MacLeod, Onofrey and Norris (1954) for certain marine bacteria. Some organisms in our collection, such as 14 and 8, however, grow well in the basal medium containing $(NH_4)_2SO_4$ and suitable carbon sources (not glucose alone), without added amino acids.

Studies on the utilization of single amino acids as sources of carbon and energy in the presence of $(NH_4)_2SO_4$, and as a sole source of nitrogen in the presence of 0.2 per cent dextrose, have revealed something concerning the availability of these compounds for growth of a few organisms. The amino acids, alanine, proline, aspartic and glutamic acids were used in basal phosphate—artificial sea water medium, with dextrose or $(NH_4)_2SO_4$, and inoculated with species of *Pseudomonas* and *Serratia*. Under the conditions of the experiment, these amino acids appear not to be very good

TABLE 4. *Growth of twelve bacterial isolates in the presence of single amino acids or combinations of amino acids, and other carbon sources added to synthetic sea water medium containing* $(NH_4)_2SO_4$.

Organisms	1	2	14	11	4	5	9	24	6	10	8 red	8 white
Sources of Carbon & energy												
Glucose + glycerol + succinate	24	70	81	15	31	66	20	6	70	34	98	34
Casamino acids	37	70	83	46	74	64	63	49	64	67	51	12
Casamino acids + glucose + glycerol + succinate	81	88	95	92	92	82	80	61	92	73	99	79
Group A	2	3	2	3	19	3	3	2	2	29	4	4
Group B	1	3	20	9	2	2	1	0	0	20	2	2
Group C	1	1	5	2	4	4	1	2	6	4	4	2
Group D	36	69	91	52	30	49	69	37	72	78	31	25
Alanine + aspartic acid	29	49	83	34	10	35	46	28	55	9	14	22
Alanine + glutamic acid	22	50	88	4	17	18	5	22	31	65	6	6
Aspartic acid + glutamic acid	0	45	24	2	2	33	0	10	11	72	37	45
Alanine	5	22	62	1	1	7	12	4	12	3	1	1
Aspartic acid	3	5	6	2	0	3	0	12	7	15	8	6
Glutamic acid	40	27	2	3	3	3	4	3	15	13	17	7
Arginine	6	23	9	2	4	4	3	1	1	13	3	3
Proline	9	42	13	2	3	18	5	3	11	34	42	10

Growth = 100-percent transmission of incident light in a Coleman spectrophotometer at 610 mμ; uninoculated medium = 0; cultures incubated in tubes containing 10 ml. of medium and inclined on a rotary shaker for 72 hours at 25° C. The per cent of each amino acid used (in artificial sea water and neutralized) was as follows. Group A: DL-phenyl alanine, 0.08; L-tyrosine, 0.04; DL-tryptophan, 0.08; DL-valine, 0.08; L-leucine, 0.04; DL-isoleucine, 0.08. Group B: L-lysine · HCL, 0.08; DL-methionine, 0.08; L-cystine, 0.04; L-arginine · HCL, 0.08; L-proline, 0.04; L-histidine, 0.04. Group C: DL-serine, 0.08; glycine, 0.04. Group D: DL-alanine, 0.04; DL-aspartic acid, 0.16; L-glutamic acid, 0.2.

sources of carbon and energy, but for some isolates each served well as the single source of nitrogen. In some isolates, *e.g.* 2, however, they appeared to be used better as a sole source of carbon and energy than as a nitrogen source. The qualitative and quantitative relations in amino acid nutrition of marine bacteria seem to be a relatively complicated problem.

Using basal artificial sea water medium supplemented with 0.1 per cent Difco casamino acids as a source of nitrogen, it was found feasible to study the utilization of various carbon compounds added at the 0.5 per cent level. The results obtained with twelve cultures grown upon six different com-

pounds of carbon are shown in table 5. Glycerol, succinate, citrate, and to a lesser extent dextrose and starch, are available for growth of these organisms in varying degrees. Five of the isolates exhibited traces of growth in the basal medium.

When these cultures were grown in Difco nutrient broth, made in sea water and in fresh water, it was found that nine out of twelve grew well in sea water medium but failed to grow in the more dilute fresh water medium. The isolates designated as 1, 2, 4, 5, 6, 24, 8 red and 8 white are among the group possessing a requirement for sea water medium.

TABLE 5. *Comparative growth of organisms in a medium containing different individual carbon compounds as a source of carbon and energy in the presence of 0.1% casamino acids as the source of nitrogen.*

Carbon Compound	Na Acetate	Na Succinate	Na Citrate	Glycerol	Dextrose	Soluble Starch	Basal Medium
Organism							
1	25	30	6	14	28	28	3
2	26	66	72	71	68	56	22
14	44	60	45	73	20	50	6
11	16	41	1	24	37	16	5
4	37	58	38	26	40	59	25
5	14	26	8	56	37	30	1
9	14	78	0	10	16	18	13
24	9	77	5	9	21	6	5
6	21	55	46	22	45	16	4
10	61	66	72	74	36	58	29
8 red	49	62	50	80	17	55	1
8 white	40	72	70	78	12	56	19

Growth = 100 – T; 72 hours incubation at 25° C on a shaker.
Medium: 0.1% casamino acids, 0.5% carbon compound, 0.015% equimixture of $K_2HPO_4 + KH_2PO_4$, and artificial sea water.

These same organisms were inoculated into Difco nutrient broth made in different concentrations of artificial sea water, over the range from distilled water to ×2 ordinary sea water and allowed to incubate for 48 hours on a rotary shaker. Growth varied in relation to concentration of diluent in different patterns, as is illustrated in figure 5. Culture 6 shows a rapid rise in amount of growth up to about ×0.3 the concentration of normal sea water, with little variation upward to ×2.0 concentration. Culture 8 (red strain) shows a steady rise of growth up to about the level of normal sea water, and a decrease at 1.8–2.0 times normal sea water. Organism 1 in contrast to these, exhibits a rise to 0.5 concentration, and beyond a concentration of about 1.1 shows a rapid decrease in growth with increasing salt content of the media.

Further contrasting responses to variations in salt concentration, and different proportions of dextrose and casamino acids, is exemplified by experiments reported in figure 6 for the isolates 8 (*Serratia*) and 2 (*Pseudo-*

monas). Media were made in artificial sea water $\times 0.5$ and $\times 1.0$. In each of these, dextrose was kept at the 1.0 per cent level and casamino acids were varied over a range from 0 to 2.0 per cent. Series were set up also, with dextrose varied over the range from 0 to 2.0 per cent, with casamino acids

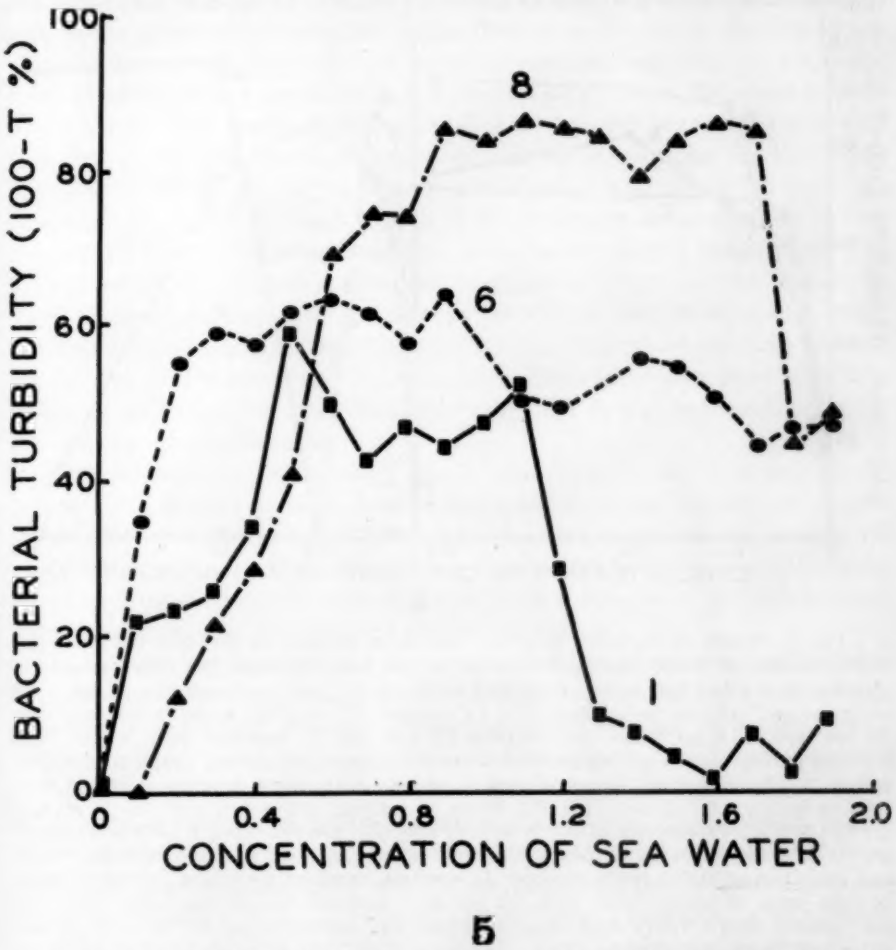

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FIG. 5. Growth of three isolates 1, 6 and 8, in Difco nutrient broth made in different concentrations of artificial sea water from 0 to 2.0 times normal sea water. All three organisms show increasing growth with increasing concentration over the lower range. Culture 1 shows strong inhibition at the higher levels of salt concentration.

maintained constant at 0.1 per cent. In full strength sea water, growth of *Serratia* (8 red) is limited to a narrow range of dextrose concentrations with a minimum near 0.2 per cent. With $\times 0.5$ sea water the range of growth is extended to about 1.0 per cent dextrose. *Pseudomonas* (2), in con-

trast, shows growth increasing with dextrose or casamino acids and no decrease over the range of substrates to 2 per cent, in both concentrations of artificial sea water. It is of interest to point out, that growth of *Serratia* (8 red) is not inhibited with 1 percent dextrose in × 1.0 sea water, provided that casamino acids are present above 1 per cent. It appears that some un-

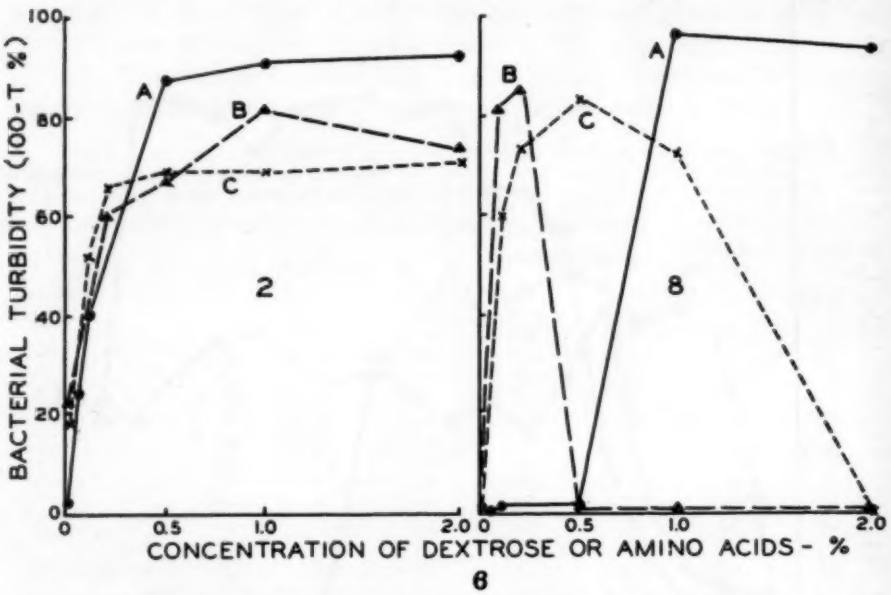

FIG. 6. Growth of bacterial isolates 2 and 8, in relation to different levels of dextrose or casamino acids, ranging from 0 to 2.0 per cent, and with two different concentrations of artifical sea water, × 0.5 and × 1.0. A, 0.1 per cent casamino acids, × 1.0 sea water and dextrose varied from 0 to 2.0 per cent. B, casamino acids varied from 0 to 2.0 per cent, × 1.0 sea water, and dextrose 1.0 per cent. C, casamino acids varied from 0 to 2.0 per cent, × 0.5 sea water, and dextrose 1.0 per cent. In the graph to the left, culture 2 (*Pseudomonas*) shows increasing growth with rising concentrations of dextrose in both × 1.0 (A) and × 0.5 (C) levels of artificial sea water, and also increasing growth with higher supplies of casein hydrolysate (B). On the right, 8 (*Serratia*) shows growth in a narrow range of dextrose concentration (B) with × 1.0 strength sea water, and inhibition at higher levels of sugar. In contrast, excellent growth of culture 8 occurs at high levels of amino acids with 1.0 per cent dextrose in × 1.0 sea water (A), and good growth over a fairly wide range of amino acid concentration in × 0.5 strength sea water and 1 per cent dextrose (C).

favorable feature of dextrose metabolism is overcome in such a medium by the presence of casamino acids.

An experiment was performed to test the growth of *Serratia* (8 red) in relation to varied levels of glutamic acid up to 0.04 molar in synthetic sea water medium containing phosphate (KH_2PO_4 0.008 gm., and K_2HPO_4 0.008 gm./1.) and dextrose (0.2%). The results indicate that maximum growth is attained after about 15 hours and varies with concentration of

the nitrogen source, while generation time is inversely related to the level of glutamic acid supplied in the media.

Investigators have frequently employed peptone solutions in aged sea water in order to obtain excellent growth of marine bacteria (ZoBell 1934). With this in mind, we studied growth of a number of bacteria, known to be able to use grass extract medium, when they were allowed to develop in sea water media containing (a) 1.0 per cent of added peptone, and (b) extracted fresh grass solids at a concentration of about 1.25 per cent. Excellent growth was obtained with many of these estuarine and marsh bacteria in either of these two media. Another useful medium consists of sea water enriched with phosphates (0.016 gm./1.), 1.0 per cent dextrose and about 1.0 per cent casamino acids or N-Z Case. Growth of ten isolates was determined in this type of medium, containing casamino acids varied over a range from 0 to 2.0 per cent. All ten cultures showed rising growth curves with increasing doses of casein hydrolysate up to about the 1.0 per cent level, above which there was only a slight further increase. Six out of these ten cultures, including species of *Pseudomonas, Serratia,* and *Flavobacterium* gave turbidity values of 90 or greater after 24 hours of growth in medium containing 1.0 per cent casein amino acids.

Discussion. Of approximately one hundred and twenty five isolates obtained from marine mud and estuarine waters in the vicinity of Sapelo Island, Georgia, about two dozen were selected for the special studies reported in this paper. Most of these organisms appear to be pseudomonads, though red and white variants of *Serratia,* and species of *Aerobacter* and *Flavobacterium* also were present among the isolates.

In considering the nutrient requirements of these cultures, amino acids appeared to be very important. Excellent growth of all cultures studied was obtained in sea water medium containing either peptone or casein hydrolysate. Mixtures of several amino acids, notably aspartic acid, glutamic acid and alanine, provided a better medium than any single amino acid. These results are in agreement with the studies of MacLeod, Onofrey and Norris (1954) on bacteria from the Pacific Ocean. Many organisms isolated from marsh muds were able to grow well on sea water extracts of *Spartina* grass, which is abundant in the habitat of the bacteria. The amino acid requirement of these isolates is probably supplied chiefly by marsh grass, mud organisms, and plankton crops in the natural environment. The large numbers of bacteria present in the marine muds of the Georgia sea island region appear to be dormant there as opportunists, capable of rapid growth responses to suitable protein stuffs contributed by primary producers of organic matter. We have shown the importance of marine bacteria participating in rapid decomposition and conversion of readily available fractions of *Spartina.* Our studies indicate that the crude fiber material in *Spartina*

is decomposed slowly. The role of different types of microorganisms in the slower digestion of cellulose and lignin in the sea is an important biological problem that awaits intensive study.

The requirement of sea water by marine bacteria, rather than fresh or distilled water, for growth in complex media, on primary isolation, has been used in the past to differentiate them from land forms (ZoBell and Upham 1944). MacLeod, Onofrey and Norris (1954) and MacLeod and Onofrey (1956) have shown that artificial sea water, such as that of Lyman and Fleming (1940), can be substituted for natural sea water. In addition, MacLeod and Onofrey (1956) reported that growth of their marine organisms was increased by using either natural or artificial sea water at half strength. Their studies support the idea that true marine bacteria may prove to be distinguishable from land forms, by having a readily detectable need for the sodium ion. One would expect bacteria isolated from estuarine regions to consist of both adaptable terrigenous and marine species. Out of 125 isolates studied from the Georgia sea island area, about eleven per cent were found to be euryhaline, growing in either sea water nutrient broth or in standard nutrient medium made with distilled water.

The appreciable number of bacteria that were found capable of growing well upon constituents of marsh grass in sea water medium indicates the great potential value of this primary source of organic material for supporting the complex flora and fauna of the coastal waters. Participation of bacteria and protozoa in the conversion of grass constituents to a higher content of mixed vegetable and animal protein has been reported by Taschdjian (1954). He applied for a patent on the microbial production of food protein from marsh grass, but no calculations were made on the carbon and energy balance of the process. It is apparent from our laboratory and field studies that microbial transformation of grass residues constitutes a very important link in the nutritional chain of marsh grass and adjacent waters. It is probable that conversion of substrates by marine bacteria may provide food stuffs of better quality for the marine fauna with exacting nutritional requirements. Change in biological value of proteins by bacterial conversion of organic substrates in sea water media is being studied further.

SUMMARY

1. Aerobic, heterotrophic, marine bacteria have been found to participate actively in the decomposition of *Spartina*, both in the field and in the laboratory. Thirty-five per cent of 125 isolates obtained from sea water and marsh mud near Sapelo Island, Georgia, grew in sea water marsh grass extract medium more luxuriantly than in sea water Difco nutrient broth.

2. Assuming similar relationships to hold in nature and in the laboratory quantititive data provided an estimate that about eleven per cent of the

annual crop of marsh grass may be rapidly converted to bacteria (dry weight basis). Microbial utilization of crude fiber takes place more slowly than decomposition and use of protein and soluble carbohydrate constituents.

3. Marsh mud extracts failed to serve as an enrichment medium for aerobic heterotrophic bacteria unless supplemented with organic materials, such as casein hydrolysate or grass extract. Supplements of dextrose, phosphate, or ammonium nitrate were generally ineffective. Numerous bacterial isolates from water and mud were able to grow well on extracts of *Spartina* in either natural or artificial sea water.

4. Bacterial isolates did not possess specific requirements for single amino acids, although growth in the presence of sources of amino nitrogen was generally better than on ammonium sulfate. Growth in the presence of multiple mixtures of pure amino acids or hydrolysed casein was better than growth on single amino acids. Among the combinations of pure amino acids studied, a mixture of alanine, aspartic acid, and glutamic acid yielded very good growth.

5. In the estuarine waters of the Georgia sea island region, where salinity varies greatly with changes in the seasons and tides, both euryhaline and stenohaline types of bacteria occur as natural adaptations to the fluctuating conditions of the environment.

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THE OCCURRENCE OF CODIUM IN LONG ISLAND WATERS

G. B. BOUCK[1] AND E. MORGAN

The occurrence of *Codium* on our northeastern American coast has been long awaited. In 1858 Harvey spoke of it as being a well known and common plant found in every latitude from the equator to the colder parts of the temperate zone and nearly to the Polar Basin, yet still not a native to the eastern coast of North America. Farlow (1881) described *Codium* as being nearly ubiquitous in distribution although not yet established on our northern coast. There is one dubious reference by Farlow (1893) to a single herbarium sheet of *Codium* reported to have been collected from Greenport, L.I. However Farlow stated that the label on this sheet was probably an error, although Greenport is not far from the station reported below. The name of the collector is not given, and efforts to locate the sheet in question have not been successful. Taylor (1937) and Silva (1955) do not record *Codium* on the northeastern coast of North America.

Nearly one hundred years after Harvey's observation, on January 13, 1957, five large bushy plants of *Codium* were found at East Marion, Long Island, New York. These seemed to be in good condition and some were even in fruit. Four of the plants had holdfasts attached to the dorsal surface of *Crepidula fornicata* shells. The obvious luxuriance of the plants in addition to their dark green color would seem to indicate that they had not traveled a great distance. The species was identified by Dr. Paul Silva of the University of Illinois as *C. fragile* (Sur.) Hariot subsp. *tomentosoides* (van Goor) Silva. Up to the present this plant had not been found in North America. It is apparently a native of Japan, and has been reported in recent years from various parts of Europe (Silva 1955).

C. fragile subsp. *tomentosoides* is commonly regarded as a weed among marine algae due to its ability to survive under adverse conditions and crowd out other forms. This is borne out, it would seem, by the fact that the plant was found in water a little above freezing, and which was within a week's time entirely covered with a layer of ice. It was not until February 3, 1957, that conditions were favorable for further collecting. At this time additional plants were picked up that had been cast ashore, but they were not as vigorous as those of the first find. They had lost some of their color, and might have been left over from the material washed ashore at the first date and merely overlooked at that time. However, on February 24, 1957,

[1] It is a pleasure to express my appreciation to Professor E. B. Matzke, Columbia University, for his assistance in the preparation of this paper.

one bushy green plant with dark tips was found floating in approximately the same area. This was also attached to *Crepidula*.

It would seem that *Crepidula*, which often grows on other *Crepidula* shells, dies and becomes detached from its substratum. The shell with the plant attached then floats ashore at the whim of wind and tide currents. None of the molluscs to which the *Codium* was attached were found to be alive at the time of discovery.

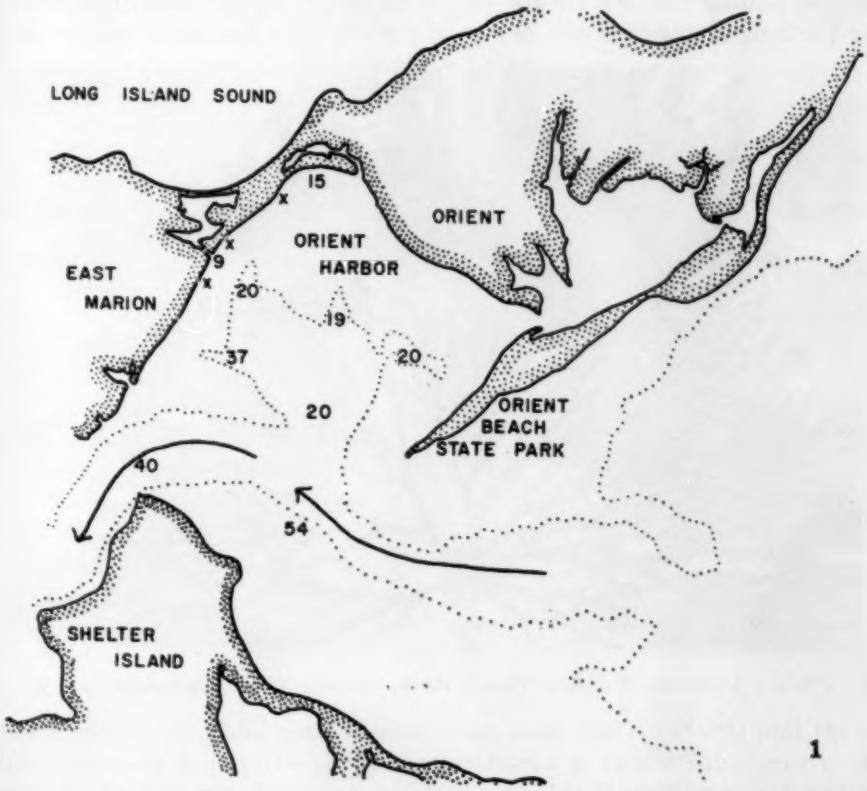

FIG. 1 : Map of the Orient Harbor area. Numbers indicate depth in feet of water. X's show approximate areas of collections, and arrows describe the main tidal current channel. (Reproduced from U.S. Coast and Geodetic Survey Chart #363; 1952)

A cursory examination of the area in which the plants were found revealed nothing significantly different either in the salinity, which varied from 11–12% of saturation, or the temperature of the water, when compared with recordings of salinity and temperature made on Peconic Bay a short distance away. However, the measurements were made at low tide and only as far out as could be reached with ordinary hipboots, so perhaps conditions

further out might show some variation. The water reached a depth of 20 feet about five hundred yards offshore, and a depth of 37 feet in one depression approximately fifteen hundred yards from the place where the *Codium* was first collected. The entire body of water which comprises Orient Harbor (fig. 1) is a relatively protected, quiet area which is out of the main tidal current channel. It is bounded on the south by Orient State Park, on the east by the land around the Village of Orient, and on the north by the strip of land joining East Marion and Orient Village. It is conceivable that plants or portions of plants could be brought along with the main current and

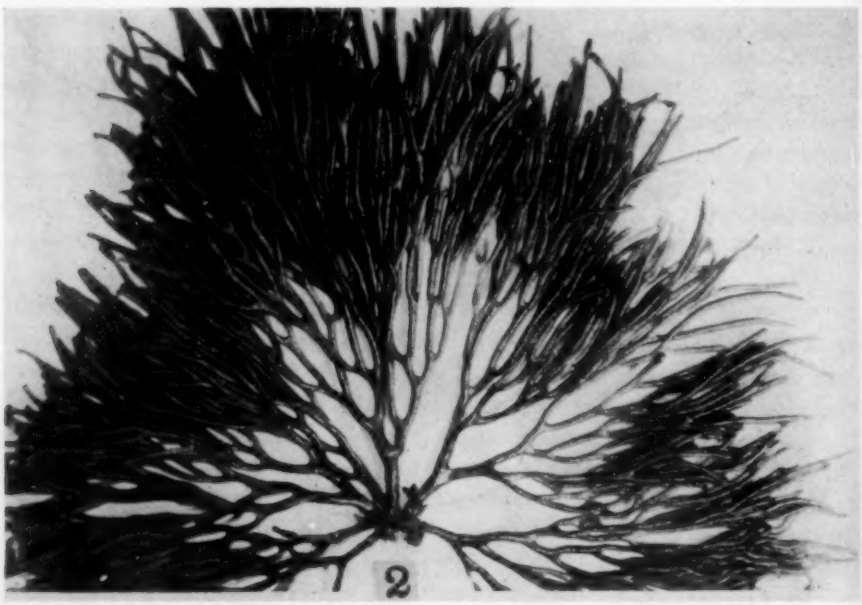

FIG. 2 : A portion of *Codium fragile* subsp. *tomentosoides*. (approximately × ⅓)

swept into this bay. Once there the relatively deep and quiet water might favor survival. Perhaps of significance in interpreting how favorable conditions for growth are in this area is the occurrence in the past of a rather unique growth of *Spongomorpha arcta* (Dillwyn) Kutzing. This is a green alga which reaches its greatest luxuriance in late winter. In Orient Harbor this plant reaches proportions greater than those of any of the plants collected in other parts of Long Island—the diameter of free floating members often exceeding 10 inches.

The species of *Codium* native to the eastern coast of the United States, such as those found south of Beaufort, N.C., are apparently unable to make the transition to northern conditions. One would therefore suspect that if, after all this time, these species progressed no further north, this must be

a species entirely new to our coast, capable of withstanding a variety of ecological conditions, and one hardy enough to survive the rather severe temperatures of our nothern waters. *Codium fragile* seems to be the *Codium* best suited to meet these conditions.

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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 84, NO. 5, pp. 388–397 SEPTEMBER, 1957

TORREYA

Resin Cavity Pattern in the Needles of Black, Red and White Spruce

MAXIMILIAN G. DUMAN

Sargent (1898) illustrated the cross sections of the needles of white spruce (*Picea glauca* (Moench) Voss), red spruce (*P. rubens* Sarg.) and black spruce (*P. mariana* (Mill.) BSP.) with twi resin cavities. Marco (1931) pointed out that Sargent's illustrations of the cross sections of the needles of Engelmann spruce (*P. engelmanni* (Parry) Engel.) showing no resin cavities, and blue spruce (*P. pungens* Engel.) showing one resin cavity are misleading. Reed and Freytag (1949) indicated that it is possible to distinguish the resin sacs in fresh needles of the latter two species with the aid of a dissecting microscope, and that they occur as relatively short discontinuous units in contrast with the long continuous type of resin ducts in the needles of the pines.

We have found that the resin cavities in dry spruce needles which are first boiled in water and then treated with alcohol can be distinguished under the dissecting microscope with the aid of transmitted light. If the needles are cleared with xylene or oil of wintergreen the cavities become even more distinct.

Our study indicates that the needles of the black spruce and red spruce have two continuous resin ducts running from base to tip. Every cross section of these needles will always show two resin ducts. The needles of the white spruce, however, have resin sacs arranged in longitudinal series interrupted by transverse partitions of mesophyll. A cross section of a white spruce needle may show two resin sacs, one resin sac, or no resin sacs. In 100 cross sections made at random only 10 had two, 38 had one, and 52 had no resin sacs.

A study of the needles of the white spruce with a dissecting microscope confirmed that the possible cross sections showing two resin sacs were relatively few. The possibility of making two cross sections from different parts of the same needle each showing two resin sacs was rare. In none of the many needles examined would it have been possible to make three cross sections at different levels each showing two resin sacs.

In the field several cross sections cut with a sharp knife and examined with a strong lens will reveal the type of resin cavity present. This can be helpful in distinguishing between black spruce and white spruce seedlings as well as depauperate specimens so frequently found in the higher latitudes.

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An Annotated Preliminary Catalogue of the Vascular Flora of Rockland County, New York

(Continued from Bull. Torrey Club **84**: 310–317, 1957.)

J. HARRY LEHR

COMPOSITAE

VERNONIA

VERNONIA NOVEBORACENSIS (L.) Michx. New York Ironweed. Clarkestown, Ramapo. (H)

Eupatorium

*Eupatorium dubium Willd. Joe-Pye-Weed. Ramapo. (H)
E. fistulosum Barratt. Trumpet-Weed. Ramapo. (H)
E. perfoliatum L. Boneset. General. (H)
*E. purpureum L. Sweet Joe-Pye-Weed. Haverstraw. (H)
E. rugosum Houtt. White Snakeroot. General. (H)

Mikania

Mikania scandens (L.) Willd. Climbing Hempweed. Ramapo, Orangetown. (H)

Solidago

*Solidago altissima L. Tall Goldenrod. Clarkestown. (H)
*S. arguta Ait. Cut-leaved Goldenrod. A single station for this rarity in the southern part of New York State. Clarkestown. (H)
*S. asperula Desf. Orangetown. This hybrid is found at only one of the two stations where both parents (*S. rugosa* and *S. sempervirens*) grow in close association. (H)
S. bicolor L. White Goldenrod. General. (H)
S. caesia L. Blue-stemmed Goldenrod. General. (H)
S. flexicaulis L. Broad-leaved Goldenrod. General. (H)
S. gigantea Ait. Late Goldenrod. Clarkestown, Ramapo. (H)
S. graminifolia (L.) Salis. Lance-leaved Goldenrod. General. (H)
S. juncea Ait. Early Goldenrod. General. (H)
*S. nemoralis Ait. Gray Goldenrod. Ramapo, Stony Point. (H)
*S. odora Ait. Sweet Goldenrod. Stony Point, Haverstraw. (H)
*S. patula Muhl. Swamp Goldenrod. Ramapo, Clarkestown. (H)
*S. rigida L. Stiff Goldenrod. A single station for this, another rarity in the southern part of New York State. (H)
S. rugosa Ait. Rough Goldenrod. General. (H)
S. sempervirens L. Seaside Goldenrod. Orangetown, Stony Point. (H)
*S. squarrosa Muhl. Stout Goldenrod. Orangetown. (H)

Aster

*Aster acuminatus Michx. Mountain Aster. Ramapo. (H)
A. acuminatus Michx. forma subverticillatus Fern. Whorled Aster. The form is more common in this county than the typical species. Clarkestown, Ramapo. (H)
A. cordifolius L. Heart-leaved Aster. General. (H)
A. dumosus L. Bushy Aster. Ramapo. (H)
*A. laevis L. Smooth Aster. Ramapo. (H)
A. lateriflorus (L.) Britt. Calico Aster. Ramapo. (H)
A. linariifolius (L.) Stiff-leaved Aster. Stony Point, Ramapo. (H)
A. Lowrieanus Porter var. lanceolatus Porter. Lowrie's Aster. Ramapo. (H)
A. macrophyllus L. Large-leaved Aster. Ramapo. (H)
A. novae-angliae L. New England Aster. General. (H)
A. patens Ait. Late Aster. Ramapo. (H)
A. pilosus Willd. var. demotus Blake. White Heath Aster. Ramapo. (H)
*A. prealtus Poir. Willow Aster. Orangetown. (H)
*A. prenanthoides Muhl. Crooked-stemmed Aster. A rarity in the southern part of New York State. Ramapo. (H)
A. puniceus L. Purple-stemmed Aster. Ramapo. (H)
*A. Schreberi Nees. Schreber's Aster. Ramapo. (H)
A. subulatus Michx. Salt-Marsh Aster. Orangetown. (H)
A. umbellatus Mill. Flat-topped White Aster. Ramapo. (H)
*A. undulatus L. Wavy-leaved Aster. Ramapo. (H)

ERIGERON

ERIGERON ANNUUS (L.) Pers. Whitetop. General. (H)
E. CANADENSIS L. Fleabane. General. (H)
E. PULCHELLUS Michx. Robin's-Plantain. Ramapo, Stony Point. (H)
*E. STRIGOSUS Muhl. Rough Daisy Fleabane. General. (H)

SERICOCARPUS

SERICOCARPUS ASTEROIDES (L.) BSP. White-topped Aster. Ramapo, Haverstraw. (H)

PLUCHEA

PLUCHEA PURPURASCENS (Sw.) DC. var. SUCCULENTA Fern. Salt-Marsh-Fleabane. The author believes that this is the northernmost station in the State with one exception, the salt marshes of Onondaga Lake near Syracuse. Orangetown. (H)

ANTENNARIA

The author has not completed his collections and studies in this taxon.

ANAPHALIS

ANAPHALIS MARGARITACEA (L.) C. B. Clarke. Pearly-Everlasting. Ramapo. (H)

GNAPHALIUM

GNAPHALIUM OBTUSIFOLIUM L. Fragrant Everlasting. Orangetown, Clarkestown. (H)
*G. ULIGINOSUM L. Low Cudweed. Ramapo. (H)

IVA

*IVA FRUTESCENS L. var. ORARIA (Bartlett) Fern. & Grisc. Marsh-Elder. The author believes this is the northernmost station in New York State. Orangetown. (H)

AMBROSIA

AMBROSIA ARTEMISIIFOLIA L. Ragweed. General. (H)
A. TRIFIDA L. Giant Ragweed. General. (H)

ECLIPTA

ECLIPTA ALBA L. Yerba-de-Tago. This is another species which the author believes is at the northernmost limit of its range in New York State at this station. Orangetown. (H)

RUDBECKIA

RUDBECKIA HIRTA L. Black-eyed Susan. General. (H)
R. LACINIATA L. Tall Coneflower. Ramapo, Clarkestown. (H)

HELIANTHUS

*HELIANTHUS ANNUUS L. Sunflower. Ramapo. (H)
H. DECAPETALUS L. Thin-leaved Sunflower. Ramapo. (H)
H. DIVARICATUS L. Woodland, Sunflower. Haverstraw. (H)
H. GIGANTEUS L. Tall Sunflower. Clarkestown. (H)
H. STRUMOSUS L. Pale-leaved Sunflower. Ramapo. (H)
H. TUBEROSUS L. Jerusalem Artichoke. Ramapo. (H)

BIDENS

BIDENS BIPINNATA L. Spanish Needle. Orangetown, Clarkestown, Stony Point. (H)
B. CERNUA L. Stick-Tight. Ramapo. (H)

*B. COMOSA (Gray) Wieg. Leafy-bracted Tickseed. (H)
B. CONNATA Muhl. var. PETIOLATA (Nutt.) Farwell. Purple-stemmed Swamp Beggar-Ticks. Ramapo. (H)
B. FRONDOSA L. Beggar-Tick. General. (H)
B. LAEVIS (L.) BSP. Large Bur Marigold. A single station for this, the most floriferous of the *Bidens*.

GALINSOGA

GALINSOGA PARVIFLORA Cav. Quick-Weed. General. (H)

HELENIUM

HELENIUM AUTUMNALE L. Sneezeweed. Ramapo, Stony Point, Clarkestown. (H)

ACHILLEA

ACHILLEA MILLEFOLIUM L. Yarrow. General. (H)

ANTHEMIS

ANTHEMIS COTULA L. Mayweed. Ramapo, Clarkestown. (H)

CHRYSANTHEMUM

CHRYSANTHEMUM LEUCANTHEMUM L. var. PINNATIFIDUM Lecoq & Lamotte. Ox-Eye Daisy. General. (H)

TANACETUM

TANACETUM VULGARE L. Tansy. Haverstraw. (H)

ARTEMISIA

ARTEMISIA VULGARIS L. Mugwort. Ramapo. (H)

TUSSILAGO

TUSSILAGO FARFARA L. Coltsfoot. General. (H)

ERECHTITES

ERECHTITES HIERACIFOLIA (L.) Raf. Fireweed. General. (H)

SENECIO

SENECIO AUREUS L. Golden Ragwort. Ramapo, Clarkestown. (H)
*S. OBOVATUS Muhl. Round-leaved Squaw-weed. Clarkestown. (H)

ARCTIUM

ARCTIUM LAPPA L. Great Burdock. General.
A. MINUS (Hill) Bernh. Smaller Burdock. General.

CIRSIUM

CIRSIUM ARVENSE (L.) Scop. Canada Thistle. Clarkestown. (H)
C. DISCOLOR (Muhl.) Spreng. Field Thistle. Clarkestown. (H)
*C. DISCOLOR (Muhl.) Spreng. forma ALBIFLORUM (Britt.) House. White Field Thistle. Orangetown.
C. MUTICUM Michx. Swamp Thistle. Clarkestown, Ramapo. (H)
C. VULGARE (Savi) Tenore. Bull Thistle. General. (H)

CENTAUREA

*CENTAUREA MACULOSA Lam. Spotted Knapweed. Clarkestown. (H)

LAPSANA

*LAPSANA COMMUNIS L. Nipplewort. A rare adventive fully naturalized at a single station. Ramapo. (H)

CICHORIUM

CICHORIUM INTYBUS L. Chicory. General. (H)

KRIGIA

KRIGIA BIFLORA (Walt.) Blake. Virginia Goat's Beard. Ramapo, Clarkestown. (H)
*K. VIRGINICA (L.) Willd. Canada Dwarf Dandelion. Clarkestown. (H)

TRAGOPOGON

TRAGOPOGON MAJOR Jacq. Goat's Beard. Ramapo, Clarkestown. (H)

TARAXACUM

TARAXACUM OFFICIONALE Weber. Common Dandelion. General. (H)

SONCHUS

*SONCHUS ASPER (L.) Hill forma GLANDULOSA Beckh. Spiny-leaved Sow-Thistle. Ramapo. (H)
*S. OLERACEUS L. Common Sow-Thistle. Ramapo. (H)

LACTUCA

LACTUCA BIENNIS (Moench) Fern. Tall Blue Lettuce. General. (H)
*L. CANADENSIS L. Tall Lettuce. Clarkestown. (H)
*L. SCARIOLA L. Wild Lettuce. Orangetown. (H)

PRENANTHES

PRENANTHES ALTISSIMA L. Tall White Lettuce. Ramapo, Clarkestown. (H)
P. TRIPOLIATA (Cass.) Fern. Tall Rattlesnake Root. Clarkestown, Haverstraw. (H)

HIERACIUM

HIERACIUM AURANTIACUM L. Orange Hawkweed. Found only occasionally; cannot be considered a weed in this county. Clarkestown. (H)
*H. FLORENTINUM All. King-Devil. Clarkestown, Ramapo. (H)
H. GRONOVII L. Hairy Hawkweed. Clarkestown, Ramapo. (H)
H. PANICULATUM L. Panicled Hawkweed. Clarkestown. (H)
H. PRATENSE Tausch. Yellow Paintbrush. General. (H)
H. VENOSUM L. Rattlesnake Weed. Clarkestown, Haverstraw. (H)

(To be concluded)

PROCEEDINGS OF THE CLUB

MARCH 19, 1957 The meeting, at Columbia University, was called to order by President Rickett at 8:03 P.M. Thirty-four members and guest were present. The minutes of the previous meeting were approved as read.

Mr. Lawrence J. Crockett was elected to Active (Annual) Membership and Miss G. Eleanor MacLean to Associate Membership.

Dr. Rickett announced that two members of the Council were to be elected to fill the unexpired terms of Dr. John A. Small and Dr. Peter K. Nelson. The Council recommended that the following persons be elected to fill these offices:

Dr. Jennie L. S. Simpson	Term: 1955–1957
Dr. Robert Lampton	Term: 1956–1958

Dr. Rickett called for nominations from the floor; there were none. Dr. Rogers moved, seconded by Dr. Clum, that the Secretary be instructed to cast one ballot for the election of these Council Members. The vote by the members of the Club on this motion was unanimous.

Dr. Rickett announced that since there was a discrepancy between the times for the meetings recommended by the Council and subsequently voted by the Club at its March 6, 1956 meeting and the By-Laws, there should be an amendment made to the By-Laws.

The Council recommended that the following change be made:

> By-Law 2—Meetings. Delete the statement, "the regular meeting shall be held on the first Tuesday and third Wednesday of each month," and add the following: "the regular meeting of the Club shall be held on the first Tuesday of each month and a second meeting on the third Tuesday if a speaker is available." Add the sentence, "In the event the first Tuesday falls on a holiday the meeting on the third Tuesday of the month will be the regular meeting."

Dr. Clum moved that this recommendation be approved by the Members of the Club. The motion was unanimously passed.

Dr. Rickett introduced the speaker of the evening, Dr. Ulrich Naf of the Rockefeller Institute for Medical Research who spoke to the Club on, "Physiology of Antheridium Formation in *Pteridium aquilinum* (Bracken)."

After a period of lively discussion the meeting was adjourned at 8:55 P.M.

Respectfully submitted,
Frank G. Lier,
Recording Secretary

APRIL 2. The meeting of the Club, at the Brooklyn Botanic Garden, was called to order by President Rickett at 8:10 P.M. There were 25 members and guests present. The minutes of the meeting of March 19, 1957 were approved as read.

Sister Mary Annunciata, R.S.M., and Mr. Karl L. Brooks were elected to Active (Annual) Membership by the members of the Club.

Dr. Rickett introduced the speaker of the evening, Dr. Louis G. Nickell of Charles Pfizer and Company, who spoke to the Club on, "Plant Exploration in Latin America."

Dr. Nickell told the Club of his search for new sources of the drug plant Rauwolfia from which reserpine and other alkaloid drugs are derived. In addition, he collected soil samples as possible sources of new antibiotic producing organisms. The diseases of bananas in Central America were also discussed. Dr. Nickell illustrated his talk with colored and black and white lantern slides.

The meeting was adjourned at 8:50 P.M. after which coffee and refreshments were served by the members of the staff of the Brooklyn Botanic Garden.

Respectfully submitted,
Frank G. Lier,
Recording Secretary

MAY 7. The meeting of the Club, at Hunter College, was called to order by Dr. McMahon, the Treasurer, at 8:05 P.M. There were 35 members and guests present. The minutes of the meeting of April 2, 1957 were approved as read.

Mr. G. Benjamin Bouck and Mr. Thomas T. Cooke were elected to Active (Annual) Membership by the members of the Club.

The resignations of the following Active members were accepted with regret: Mr. Raymond Adolph, Dr. W. B. Baker, Mr. Alfred Bartsch, Dr. Clarence Sterling, and Dr. Robert Stratton.

Dr. McMahon introduced the speaker of the evening, Miss Jean Seear, of the Brooklyn Botanic Garden who spoke to the Club on, "Alpine Flowers of Rocky Mountain National Park." Miss Seear's talk was illustrated with excellent colored slides of the plants, animals, and scenery of the Park and its environs.

At the end of the meeting Dr. McMahon announced that the Nominating Committee had been appointed by the President. It consists of Dr. Donald P. Rogers, Chairman, Dr. Lindsay Olive, and Dr. J. L. S. Simpson.

The meeting was adjourned at 8:55 P.M. after which refreshments were served by the members of the Hunter College Faculty.

Respectfully submitted,
Frank G. Lier,
Recording Secretary

FIELD TRIP REPORTS

April 20. Willowbrook Park, Staten Island, N. Y. Early spring flowers were observed on the following plants: spring-beauty, Canada May-flower, trout-lily, spicebush, red maple, and sassafras. It was observed that the flowers were much further advanced on the edges of woodland. A pheasant was flushed from a nest on the meadow in the William T. Davis Wildlife Refuge. There were 11 eggs in the nest. Attendance 12. Leader, Mathilde Weingartner.

May 25. Ward's Point, Staten Island, N. Y. Some of the common shore birds were seen. Among the plants of interest to the group were persimmon, old-man-of-the-earth (*Ipomoea pandurata*), *Quercus Phellos*, and x *Q. Rudkini*. Several interesting grasses were observed. Attendance 12. Leader, Mathilde Weingartner.

June 9. Van Cortlandt Park, N. Y. Our first stop was at a swamp near the Woodlawn Station. Here can still be found several large-sized poison sumacs, which were just coming into bloom at the time of our visit. In the wet grounds near the sumacs were dense stands of a sterile grass that had been extensively attacked by a fungus, *Epichloë typhina* (determined by Donald P. Rogers). This ascomycete appeared as a conspicuous cream-colored (turning pale orange) band or zone 2–6 cm. broad around the apex of the host; the fungus tissue when scraped emitted a distinctive smell like that of our ordinary mushrooms. It had infested the one species only, although *Glyceria striata* and *Poa trivialis* were abundant nearby. Dr. Rogers informs us that this fungus is poorly represented for America in the herbarium. Is the parasitized grass *Glyceria melicaria?* The writer seems to recall seeing that species in the swamp many years ago.

On the way toward the East Woods, we unsuccessfully looked for *Lepidium perfoliatum*, which the leader had collected the week before on a roadside embankment where it must have come in recently. The plant was scarce but seeding well; the flowers were yellowish. The clasping pepper-grass is not mentioned by Taylor in his Flora of the Vicinity of New York, but it had been collected as early as 1895 by Bicknell in the Yonkers' Wool Mill. On a newly-made lawn in the vicinity of the pepper-grass, there were many plants of *Vicia tetrasperma;* the tiny flowers were about 4 mm. long, not "7–8 mm.", as described by Fernald.

We concluded the outing with a quiet stroll in the low, rather monotonous oak-woodland of East Van Cortlandt Park. The leader wishes to make the following comments about some of the plants examined: *Agastache nepetoides*, first seen by him in the East Woods over ten years ago, is still flourishing. The sharply 4-angled fistulous stems are like those of *Mimulus alatus*. Fernald describes the leaves as "glabrous or essentially so"; however, they are minutely and closely hirtellous, particularly beneath. We examined the spicy-fragrant staminate flowers of *Vitis labrusca* and found them to be about equally 5- and 6-merous, notwithstanding the agreement on the categorical 5-merous by the two latest standard floras. *Rhododendron viscosum* apparently is pictured twice in the New Britton and Brown, both under the proper name and *R. serrulatum*. The illustration of the latter is based on *Gleason 8560* from Virginia, subsequently determined as *R. viscosum* by a student of the group (H. T. Skinner, 1951). It shows the longer corolla-lobes described for *R. viscosum* rather than *R. serrulatum*. The sepals in the Van Cortlandt specimens vary to over 2 mm. long which disagrees with the

key-character "less than 1 mm. long." In the same reference work, the over-sized staminate flower of *Sanicula gregaria* is shown with sepals subulate-tipped instead of "obtuse to subacute," as correctly described. The character is important for it readily distinguishes the species from all others in the Manual Range. The pistillate flower is incorrectly drawn at both ends; it lacks the stipe at the base and the long styles at the apex. Thus, for the purpose of distinguishing the species of sanicle, these illustrations are worthless and misleading. *Lysimachia quadrifolia* was seen coming into bloom. The specific name means four-leaved, but sometimes the leaves are 5 or from 3–8 in a whorl, or they may be merely opposite or even alternate. The cut rhizome and stem exude a brown or iodine-colored juice (*L. terrestris* has similar juice). The corolla-lobes are dextrorsely convolute in aestivation. There are infrequent variations in the structure of the flower. Sometimes the flowers are 4-merous; six sepals have also been observed. The filaments of the stamens are united at the base; in rare instances, very short tooth-like processes are seen alternating with the filaments, as though they were initial or vestigial staminodia. Attendance 15 members and guests. Leader, Joseph Monachino.

Book Reviews

Biogeography: An Ecological Perspective. By Pierre Dansereau. The Ronald Press Co., New York. 394 pp., 1957. ($7.50)

This book, which was written expressly "for senior and graduate students . . . to provide (them) with a new synthesis of the environmental relationships of living organisms" and for "natural scientists, geographers, and social scientists in search of an ecological inventory," covers such a wide range of subject matter that it should be of interest and value to any scientist concerned with problems of an ecological nature.

Any one of the five chapters—(1) History of Biota (2) Bioclimatology (3) Synecology (4) Autecology (5) Man's Impact on the Landscape—could be expanded into a book equal in size to the present volume. Professor Dansereau's new book is, however, something more than five-books-in-one. It is a synthesis, based on wide experience and years of teaching, that combines the essentials of historical, descriptive, and analytical vegetation science with bioclimatology and human ecology. It is a many-sided consideration of the problems of *biogeography* which is defined as "the study of the origin, distribution, adaptation, and association of plants and animals." The treatment of these problems is at once comprehensive and concise. It does much to dissolve the artificial boundaries and breech the gaps that tend to compartmentalize the various physical and biological sciences. It is not the ultimate ecological synthesis, but it is surely the longest forward step made in that direction in the past half decade.

The author's approach to his chosen subject follows that of the Zürich and Montpellier School, but he departs from tradition in many ways that are uniquely his own and in other ways that shows the influence of the American School. Only a person with Pierre Dansereau's broad and varied background could be expected to write a book so inclusive in its ultimate intentions and so cosmopolitan in its contents. The organization of the book reflects the broadest possible point-of-view. The interpretations given to the phenomena selected for consideration reflect a conversant knowledge of many contrasting ecological philosophies. The choice of examples and illustrations reflects a wide familiarity with vegetation in many parts of the world and with the ecological literature available in several languages.

The general reader will find a concise inventory of paleoecology, plant geography, bioclimatology, synecology, autecology, and human ecology, but he may find it difficult to understand. The book suggests more problems than it tells how to solve; and because it is difficult to condense so large a subject into a single volume, more space is devoted to "summing up" than to explaining principles with which the reader is assumed to be already familiar.

Students with a little training in ecological principles and methods will find the book stimulating but of a scope perhaps too large to be immediately comprehensible.

Copious cross-indexing facilitates the study of the book itself, and a generous bibliography provides a guide for further study of all the important topics considered in the text. To students unfamiliar with European concepts, the terminology may seem to be unusually large and complex, but all terms are carefully defined in an excellent glossary.

It is safe to assume that Dansereau's BIOGEOGRAPHY will do much to introduce many European concepts to American ecologists. For this reason, it is a must for the ecologist's bookshelf. This reviewer found it to be most stimulating and thought provoking. It should provide any thoughtful reader with a great many things on which to ponder and ruminate. Any biologist interested in ecology or any of its relatives would do well to own this book—and read it twice.—WILLIAM E. MARTIN, Department of Botany, Rutgers University, New Brunswick, N. J.

The Complete Book of Greenhouse Gardening. Henry T. Northen and Rebecca T. Northen. *x* plus 353 pages plus 4 color plates plus 172 halftones (63 pages) plus line drawings. The Ronald Press Company, New York, 1956. $6.50.

Here is a book to be endorsed with enthusiasm. This reviewer is in the preliminary stages of planning for a small greenhouse and has found just about everything necessary for its creation and future general upkeep in this work. In addition, it has already proven invaluable as a reference for the care and propagation of house plants produced in quantity for a recent school bazaar.

Areas covered include the selection of a greenhouse type, location, temperature and humidity provision and control, seed culture and general propagation, soils and nutrition, disease and pest control, and the specific culture methods necessary for a host of individual plants and plant types. It is especially this last area which is so valuable. Many of the horde of recent ornamental horticulture books leave the reader with a few notes in a chart to be interpreted for better or worse. The authors here provide adequate detail and well-chosen photographs along with numerous charts which then can serve their purpose with excellence. Orchids (due to the particular interest in this group by the authors) are exceptionally well covered.

It is probably the emphasis of the relationship of greenhouse gardening to house and outdoor plant culture and the inclusion of so many fine photographs that make this reference so desirable. Even the use of the greenhouse for vegetable production is included, although this seems to be the weakest area. Perhaps the other work by the same authors, THE SECRET OF THE GREEN THUMB, will add strength to this vegetable section and be of equal value concerning general gardening to this writer. He intends to purchase a copy shortly.—JOHN J. NELSON, New Brunswick Senior High School, New Brunswick, N. J.

NOTE

We have just received THE BIOTIC COMMUNITIES OF GREENBROOK SANCTUARY by Stephen Collins and published by the Palisades Nature Association, Box 230, Englewood, N. J. ($2.50) The 112 page book will be reviewed but readers may wish to get a copy for autumn reading or for reading while rambling in the Sanctuary. It appears to be well done and attractive from the very real food chain depicted on the front cover to the two maps in the pocket of the inside back cover. Collins was naturalist in the sanctuary and later did this study as a thesis for the Doctorate. Perhaps that makes its freshness and readability the more surprising! J. A. S.

Botany for Gardeners. By Harold William Rickett. vii + 236 pp. Illustrated and indexed. Macmillan, N.Y. 1957. $4.50.

This is not another of the growing line of do-it-yourself garden books; it is precisely what the title says. It is a book for those who grow plants and ought to know how they

are constructed, how they grow, and how they reproduce. The text, lucidly written, sometimes with a sly humor or probing wit, is the best example of botanical writing this reviewer has encountered in a long time. The illustrations, done by the author on stippleboard, have a clarity and grace which one seldom finds in botanical works today.

When one reviews the current crop of introductory botany texts one discovers that, in spite of all manner of gimmicks to make each unique, and publisher's jacket blurbs to the contrary, they are monotonously alike in basic concept and pedagogic approach. This little book comes like a frosty drink after weeding in the garden on a hot afternoon. While reading it a series of questions came to mind. Have we teachers become hag-ridden with mouldy traditions whose origins are forgot? Are we, as professionals, perhaps unconscious of the terrible amount of technical terminology we are forcing on the students in their introductory courses? Have we, perhaps carelessly, substituted the rote memorization of definitions for the admittedly more difficult teaching of basic concepts? If so, we are short-changing these students in their education. In this little volume Rickett has proved that the fundamentals of plant structure, metabolism and reproduction can be clearly set forth without recourse to a great spate of professional jargon, as is our custom. At a time when we botanists are vocally wondering why so few students go beyond their first course, we might perhaps do a little worrying about our methods of instruction. Have we, by attempting to include in our introductory courses some mention of almost every detail, every technical term these students would meet in their more advanced courses, built a frustratingly complex wall of terminology between our students and any possible interest they might develop in plants? With a change of title, and the addition of several topics such as ecology, plant geography, conservation, and more on the Great Groups and their development through time, Rickett might well be on his way to producing the sort of text best fitted to an introductory course in botany within the conceptual framework of the ideals of a liberal education. Once we have fixed a student's interest on the world of green, growing things there would seem to be ample opportunity, in his more advanced courses, to teach him all these intricate professional terminologies.--WENDELL H. CAMP, University of Connecticut.

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INDEX TO AMERICAN BOTANICAL LITERATURE

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LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF BRITTONIA

TAXONOMY, PHYLOGENY, AND FLORISTICS

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